DEPARTMENT OF THE NAVY (DoN)
16.A Small Business Technology Transfer (STTR)
Proposal Submission Instructions

INTRODUCTION

Responsibility for the implementation, administration, and management of the Department of the Navy (DoN) STTR Program is with the Office of Naval Research (ONR). If you have questions of a general nature regarding the DoN's STTR Program, contact Ms. Dusty Lang (dusty.lang@navy.mil). For program and administrative questions, please contact the Program Managers listed in Table 1; **do not** contact them for technical questions. For technical questions about a topic, you may contact the Topic Authors listed for each topic during the period **11 December 2015 through 10 January 2016**. Beginning **11 January 2016**, the SBIR/STTR Interactive Technical Information System (SITIS) (https://sbir.defensebusiness.org/) listed in Section 4.15.c of the DoD STTR Program Solicitation must be used for any technical inquiry. For inquiries or problems with electronic submission, contact the DoD SBIR/STTR Help Desk at 1-800-348-0787 (9:00 a.m. to 6:00 p.m. ET).

TABLE 1: DoN SYSTEMS COMMANDS (SYSCOM) STTR PROGRAM MANAGERS

Topic Numbers	Point of Contact	Activity	Email
N16A-T001 to N16A-T008	Monica Clements	NAVAIR	navair.sbir@navy.mil
N16A-T009 to N16A-T014	Mr. Dean Putnam	NAVSEA	dean.r.putnam@navy.mil
N16A-T015 to N16A-T025	Ms. Dusty Lang	ONR	dusty.lang@navy.mil

The DoN's STTR Program is a mission-oriented program that integrates the needs and requirements of the DoN's Fleet through R&D topics that have dual-use potential, but primarily address the needs of the DoN. Companies are encouraged to address the manufacturing needs of the Defense Sector in their proposals. Information on the DoN STTR Program can be found on the DoN SBIR/STTR Web site at www.navysbir.com**.** Additional information pertaining to the DoN's mission can be obtained from the DoN website at www.navy.mil**.**

PHASE I GUIDELINES

Follow the instructions in the DoD STTR Program Solicitation at https://sbir.defensebusiness.org/ for program requirements and proposal submission guidelines. Please keep in mind that Phase I should address the feasibility of a solution to the topic. It is highly recommended that proposers follow the DoN proposal template located at www.navysbir.com/submission.htm as a guide for structuring proposals. Inclusion of cost estimates for travel to the sponsoring SYSCOM's facility for one day of meetings is recommended for all proposals.

Technical Volumes that exceed **20** pages will be deemed noncompliant and will be rejected.

The DoN requires proposers to include, within the **20-page limit**, an Option that furthers the effort and will bridge the funding gap between Phase I and the Phase II start. Phase I Options are typically exercised upon the decision to fund the Phase II. **The Phase I Base amount and Period of Performance shall not exceed $80,000 and seven months**; **the Phase I Option amount and Period of Performance shall not exceed $70,000 and six months.**

Include a header with company name, DoD proposal number, and DoD topic number on each page of your Technical Volume.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

The following criteria must be met or the proposal will be deemed noncompliant and will be REJECTED.

PERFORMANCE BENCHMARKS: The DoN will NOT evaluate proposals submitted by firms that do not meet the two benchmark requirements for progress towards Commercialization as determined by the Small Business Administration (SBA) on June 1 each year. Please note that DoN applies performance benchmarks at time of proposal submission, not at time of contract award.

The Phase I Base amount and Period of Performance shall not exceed $80,000 and seven months. The Phase I Option amount and Period of Performance shall not exceed $70,000 and six months. Tasks for both the Base and the Option should be clearly identified in the 20-page Technical Volume. Costs for the Base and Option should be separate and identified on the Proposal Cover Sheet and in the Cost Volume.

BREAK OUT SUBCONTRACTOR, MATERIAL AND TRAVEL COSTS IN DETAIL. In the cost volume, it is important to provide sufficient detail for the subcontract, material and travel costs. Subcontractor costs should be detailed at the same level as the prime to include at a minimum personnel names, rate per hour, number of hours, material costs (if any), and travel costs (if any). Material costs should include at a minimum listing of items and cost per item. Travel costs should include at a minimum the purpose of the trip, number of trips, location, length of trip, and number of personnel. Use the "Explanatory Material Field" in the DoD Cost Volume worksheet for this information.

If Discretionary Technical Assistance (DTA) is proposed, add information required to support DTA in the "Explanatory Material Field" in the DoD Cost Volume worksheet. If proposing DTA, a combined total of up to $5,000 may be added to the Base and Option periods.

Upload the Technical Volume and the DoD Proposal Cover Sheet, the DoD Company Commercialization Report, and Cost Volume electronically through the DoD submission site (https://sbir.defensebusiness.org/) by 6:00 a.m. ET, 17 February 2016.

After uploading the file on the DoD SBIR/STTR submission site, review it to ensure that it appears correctly. Contact the DoD SBIR/STTR Help Desk immediately with any problems.

DISCRETIONARY TECHNICAL ASSISTANCE

The STTR Policy Directive section 9(b), allows the DoN to provide discretionary technical assistance (DTA) to its awardees to assist in minimizing the technical risks associated with STTR projects and commercializing into products and processes. Firms may request, in their Phase I and Phase II proposals, to contract these services themselves in an amount not to exceed $5,000 per year. This amount is in addition to the award amount for the Phase I or Phase II project.

Phase I awardees that propose more than $150,000 in total funding (Base, Option and DTA) may not receive a purchase order. Purchase orders are a type of Simplified Acquisition Procedure (SAP) intended to reduce administrative costs, promote efficiency and economy in contracting, and avoid unnecessary burdens for agencies and contractors. The need to issue a Firm Fixed Price (FFP) contract may result in contract delays if the SYSCOM normally issues purchase orders for Phase I awards. FOR ONR TOPICS ONLY: The total Phase I award amount, including DTA, cannot exceed $150K.

Approval of direct funding for DTA will be evaluated for approval by the DoN STTR office if the firm's proposal (1) clearly identifies the need for assistance, (2) provides details on the provider of the assistance (name and point of contact for performer); and unique skills/specific experience to carry out the assistance proposed, and (3) the cost of the required assistance (costs and hours proposed or other details on arrangement that would justify the proposed expense). This information must be included in the firm's cost proposal specifically identified as "Discretionary Technical Assistance" and cannot be subject to any profit or fee by the requesting STTR firm. In addition, the provider of the DTA may not be the requesting firm, an affiliate of the requesting firm, an affiliate of the requesting firm, an investor of the requesting firm, or a subcontractor or consultant of the requesting firm otherwise required as part of the paid portion of the research effort (e.g. research partner, consultant, tester, or administrative service provider). Failure to include the required information in the proposal will result in the request for DTA being disapproved. Exceeding proposal limits identified for Phase I ($150,000 for Base, Option, and DTA) without including the required identification of DTA will result in the proposal's REJECTION without evaluation.

If a firm requests and is awarded DTA in a Phase II proposal, it will be eliminated from participating in the DoN SBIR/STTR Transition Program (STP), the DoN Forum for SBIR/STTR Transition (FST), and any other assistance the DoN provides directly to awardees.

All Phase II awardees not receiving funds for DTA in their award must attend a one-day DoN STP meeting during the second year of the Phase II. This meeting is typically held in the summer in the Washington, D.C. area. Information can be obtained at: http://www.navysbir.com/Transition.htm. Awardees will be contacted separately regarding this program. It is recommended that Phase II cost estimates include travel to Washington, D.C. for this event.

EVALUATION AND SELECTION

The DoN will evaluate and select Phase I and Phase II proposals using the evaluation criteria in Sections 6.0 and 8.0 of the DoD STTR Program Solicitation respectively, with technical merit being most important, followed by qualifications of key personnel and commercialization potential of equal importance. Due to limited funding, the DoN reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded. **NOTE: The DoN does NOT participate in the FAST Track program.**

One week after Phase I solicitation closing, e-mail notifications that proposals have been received and processed for evaluation will be sent. Consequently, e-mail addresses on the proposal coversheets must be correct.

Requests for a debrief must be made within 15 calendar days of non-award notification. Please note the DoN debrief request period is shorter than the DoD debrief request period specified in section 4.10 of the DoD Instructions.

Protests of Phase I and II selections and awards shall be directed to the cognizant Contracting Officer for the DoN Topic Number. Contact information for Contracting Officers may be obtained from the DoN SYSCOM SBIR Program Managers listed in Table 1.

CONTRACT DELIVERABLES

Contract deliverables are typically progress reports and final reports. Deliverables required by the contract, shall be uploaded to https://www.navysbirprogram.com/navydeliverables/.

AWARD AND FUNDING LIMITATIONS

The DoN typically awards a Firm Fixed Price (FFP) contract or a small purchase agreement for Phase I. In accordance with STTR Policy Directive section 4(b)(5), there is a limit of one sequential Phase II award per firm per topic. Additionally in accordance with STTR Policy Directive section 7(i)(1), each award may not exceed the award guidelines (currently $150,000 for Phase I and $1 million for Phase II, excluding DTA) by more than 50% (SBIR/STTR program funds only) without a specific waiver granted by the SBA.

TOPIC AWARD BY OTHER THAN THE SPONSORING AGENCY

Due to specific limitations on the amount of funding and number of awards that may be awarded to a particular firm per topic using SBIR/STTR program funds (see above), Head of Agency Determinations are now required (for all awards related to topics issued in or after the SBIR 13.1/STTR 13A solicitation) before a different agency may make an award using another agency's topic. This limitation does not apply to Phase III funding. Please contact the original sponsoring agency before submitting a Phase II proposal to an agency other than the one that sponsored the original topic. (For DoN awardees, this includes other DoN SYSCOMs.)

TRANSFER BETWEEN SBIR AND STTR PROGRAMS

Section 4(b)(1)(i) of the STTR Policy Directive provides that, at the agency's discretion, projects awarded a Phase I under a solicitation for STTR may transition in Phase II to SBIR and vice versa. A firm wishing to transfer from one program to another must contact its designated technical monitor to discuss the reasons for the request and the agency's ability to support the request. The transition may be proposed prior to award or during the performance of the Phase II effort. Agency disapproval of a request to change programs will not be grounds for granting relief from any contractual requirements. All approved transitions between programs must be noted in the Phase II award or an award modification signed by the contracting officer that indicates the removal or addition of the research institution and the revised percentage of work requirements.

ADDITIONAL NOTES

Due to the short time frame associated with Phase I of the STTR process, the DoN does not recommend the submission of Phase I proposals that require the use of Human Subjects, Animal Testing, or Recombinant DNA. For example, the ability to obtain Institutional Review Board (IRB) approval for proposals that involve human subjects can take 6-12 months, and that lengthy process can be at odds with the Phase I goal for time to award. Before the DoN makes any award that involves an IRB or similar approval requirement, the proposer must demonstrate compliance with relevant regulatory approval requirements that pertain to proposals involving human, animal or recombinant DNA protocols. It will not impact the DoN's evaluation, but requiring IRB approval may delay the start time of the Phase I award and if approvals are not obtained within two months of notification of selection, the decision to award may be terminated. If the use of human, animal, and recombinant DNA use is included under a Phase I or Phase II proposal, please carefully review the requirements at http://www.onr.navy.mil/About-ONR/compliance-protections/Research-Protections/Human-Subject-Research.aspx**.** This webpage provides guidance and lists approvals that may be required before contract/work can begin.

Due to the typical length of time for approval to obtain Government Furnished Equipment (GFE), it is recommended that GFE is not proposed as part of the Phase I proposal. If GFE is proposed and is determined during the proposal evaluation process to be unavailable, proposed use of GFE may be considered a weakness in the proposal.

For topics indicating ITAR restrictions or the potential for classified work, there are generally limitations placed on disclosure of information involving topics of a classified nature or those involving export control restrictions, which may curtail or preclude the involvement of universities and certain non-profit institutions beyond the basic research level. Small businesses must structure their proposals to clearly identify the work that will be performed that is of a basic research nature and how it can be segregated from work that falls under the classification and export control restrictions. As a result, information must also be provided on how efforts can be performed in later Phases if the university/research institution is the source of critical knowledge, effort, or infrastructure (facilities and equipment).

The Naval Academy, the Naval Postgraduate School and other military academies are government organizations but now qualify as partnering research institutions. However, DoN laboratories DO NOT qualify as a research partner. DoN laboratories may be proposed only IN ADDITION TO the partnering research institution.

PHASE II GUIDELINES

All Phase I awardees will be allowed to submit an **Initial** Phase II proposal for evaluation and selection. The Phase I Final Report, Initial Phase II Proposal, and Transition Outbrief (as applicable), will be used to evaluate the offeror's potential to progress to a workable prototype in Phase II and transition technology in Phase III. Details on the due date, content, and submission requirements of the Initial Phase II proposal will be provided by the awarding SYSCOM either in the Phase I award or by subsequent notification. **NOTE: All SBIR/STTR Phase II awards made on topics from solicitations prior to FY13 will be conducted in accordance with the procedures specified in those solicitations (for all DoN topics, this means by invitation only).**

Section 4(b)(1)(ii) of the SBIR Policy Directive permits the Department of Defense and by extension the DoN, during fiscal years 2012 through 2017, to issue a Phase II award to a small business concern that did not receive a Phase I award for that R/R&D. **NOTE:** The DoN will NOT be exercising this authority for STTR Phase II awards. **Therefore, in order for any small business firm to receive a Phase II award, the firm must be a recipient of a Phase I award under that topic and submit an Initial Phase II proposal.**

The DoN typically awards a cost plus fixed fee contract for Phase II. The Phase II contracts can be structured in a way that allows for increased funding levels based on the project's transition potential. To accelerate the transition of SBIR-funded technologies to Phase III, especially those that lead to Programs of Record and fielded systems, the Commercialization Readiness Program was authorized and created as part of section 252 of the National Defense Authorization Act of Fiscal Year 2006. The statute set-aside is 1% of the available SBIR funding to be used for administrative support to accelerate transition of SBIR-developed technologies and provide non-financial resources for the firms (e.g. the DoN's SBIR/STTR Transition Program).

PHASE III GUIDELINES

A Phase III STTR award is any work that derives from, extends, or completes effort(s) performed under prior STTR funding agreements, but is funded by sources other than the STTR Program. Thus, any contract or grant where the technology is the same as, derived from, or evolved from a Phase I or a Phase II SBIR/STTR contract and awarded to the company that was awarded the Phase I/II STTR is a Phase III STTR contract. This covers any contract/grant issued as a follow-on Phase III STTR award or any contract/grant award issued as a result of a competitive process where the awardee was an STTR firm that developed the technology as a result of a Phase I or Phase II STTR. The DoN will give STTR Phase III status to any award that falls within the above-mentioned description, which includes assigning STTR Data Rights to any noncommercial technical data and/or noncommercial computer software delivered in Phase III that was developed under STTR Phase I/II effort(s). Government's prime contractors and/or their subcontractors follow the same guidelines as above and ensure that companies operating on behalf of the DoN protect the rights of the STTR company.

NAVY STTR 16.A Topic Index

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NAVY STTR 16.A Topic Descriptions

N16A-T001 TITLE: High Hesitivity Magnetic Materials for Magnetic Toroid and Flat Dipole Antennas

TECHNOLOGY AREA(S): Air Platform, Materials/Processes, Sensors

ACQUISITION PROGRAM: PMA-234 Airborne Electronic Attack Program Office

OBJECTIVE: Develop a process to produce magnetic film materials with hesitivities well in excess of currently available materials for application in magnetic toroid and flat dipole antenna elements.

DESCRIPTION: High-performance magnetic loop antennas can presently be constructed by winding a tape of thin magnetic material into the form of a loop. The same materials can be used to fabricate flat magnetic dipoles. The magnetic materials that work best have extremely high hesitivity properties [1], high enough that the magnetic field can be sustained at ultra-high frequencies (UHF). The increasing need for higher-frequency performance is driving the need for higher hesitivities. Hesitivity [1, 2 and 4] is the definitive parameter that allows for efficient categorization of magnetic materials where it measures the maximum magnetic conductivity of the material in units of ohms per meter.

Currently, CoZrNb ferromagnetic thin film material provides the highest available bulk hesitivity on the order of 6,000,000. Hesitivities of a much higher order are greatly desired with a threshold of a factor of 10 improvement. Currently these magnetic materials are formed at the atomic level by vacuum deposition of a very thin layer on a dielectric carrier film, the thickness of the carrier film dilutes the overall bulk properties of the material when layered into an antenna element, thus reducing the overall performance.

The effective hesitivity properties of such an assembly can be improved with the development of magnetic materials with higher hesitivities, and the use of thinner substrates. The substrate material must withstand the high deposition temperatures without becoming brittle or breaking during the deposition process, which involves mechanically moving the film through the deposition chamber. The solution magnetic material should improve both of these factors at once to achieve a practical effective hesitivity of an order of magnitude or more higher than what is now available.

PHASE I: Determine the technical feasibility of constructing higher hesitivity materials on very thin carrier films. Determine the practical limits of hesitivity and carrier film thickness that could be attained. Demonstrate feasibility and determine and propose a candidate alloy to be produced and applied to wide-band antennas in Phase II.

PHASE II: Further develop candidate alloy prototype for production by a viable continuous process. Verify hesitivity on prototype samples.

PHASE III DUAL USE APPLICATIONS: Finalize the selected material production process and produce quantities required to manufacture wide-bandwidth antennas for use on ground and air vehicles. The foundry that would make this product could add it to a list of offerings to other customers. End users would apply the product to antennas for wide-bandwidth applications on aircraft, ground vehicles, and potentially on fixed structures at any location where low profiles are required.

REFERENCES:

1. Sebastian, T., Diaz, R., Auckland, D. & Daniel, C. (2013). A New Realization of an Efficient Broadband Conformal Magnetic Current Dipole Antenna. Presented at the IEEE Antennas and Propagation Meeting. Orlando, FL. Retrieved from http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=6711305&url=http%3A%2F%2Fieeexplore.ieee.org%2Fxpls%2Fabs_all.jsp%3Farnumber%3D6711305

2. Sebastian, T. (2013). Magneto-dielectric Wire Antennas – Theory and Design. Arizona State University, PhD Dissertation, May 2013.

3. Diaz, R. (2014). Multi-function pseudo-conductor antennas. US Patent 8,686,918 B1

4. Auckland, D., Daniel, C. & Diaz, R. (2014). A New Type of Conformal Antennas Using Magnetic Materials. IEEE Military Communications Conference

KEYWORDS: Antennas; wide-bandwidth antennas; low profile antennas; conformal antennas; magnetic materials; magnetic hesitivity

TPOC-1: 301-342-9167

TPOC-2: 301-757-8923

Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T002 TITLE: Methods for Actionable Measures of Absolute Cognitive Workload

TECHNOLOGY AREA(S): Air Platform, Human Systems

ACQUISITION PROGRAM: PMA-202 Aircrew Systems Program Office

OBJECTIVE: Develop an innovative and cost-effective capability that will provide an objective, measurable means of workload for determining impacts on individual operator, crew-level, and/or multi-team system level performance when life support or aircrew systems are added or modified.

DESCRIPTION: In the Naval community, improving affordability is one of the main focus areas. Specifically, standardized workload management systems have been deemed one essential component to gain increased affordability. This is partly because, as the capabilities of information technology systems and networks continue to grow, workers are increasingly challenged to process more information, interact with more interconnected systems, and juggle more tasks that compete for their simultaneous attention. That is, it is critical to know human performance limitations when introducing complex, cognitive tasks and state-of-the-art technologies, equipment and new environments to warfighters. Knowledge of these limitations can help researchers and developers understand and evaluate the potentially negative impacts on safety and the efficiency of operations. Frequently, this involves assessing workload impacts; however, current workload assessment methods do not adequately support system development or enhanced decision making with objective measurements.

Current state-of-the-practice is to assess workload, either physical or cognitive, through a variety of assessment methods (Gudipati & Pennathur). The most commonly implemented is subjective measurement techniques (e.g., Bedford, Modified Cooper Harper, NASA TLX); however, there is an increased desire for more objective data on which to base decisions. A variety of objective measurement techniques exist for cognitive workload including performance measures (e.g., reaction time, errors; Kantowitz et al., 1983), psychophysiological measures, and analytical measures. Recent efforts have focused on modeling to help address concerns of limited resources and impacts of a variety of factors that affect performance (e.g., Pharmer, Paulsen, Alicia, 2011). New, cost-reducing methods are needed to support systems acquisition decisions, and these methods will need to improve on existing methods, in at least three ways, as described below.

This effort seeks to investigate a hybrid approach that would allow for the real-time measurement (e.g., measurement results as an operator tests new equipment) of physical and cognitive workload and, with the results and modeling capabilities, understand how variations in the associated factors might impact operator safety and performance. Finally, as integrated technologies and operations continue to expand, consideration beyond the individual operator to crew-level and multi-team systems is required.

The requested technology should be consistent with research and theory (e.g., Wickens, 2008), assess workload and its effect on performance, and include a strategy for predicting future workload levels once experience is accumulated. As a part of this effort, displays to indicate the rate of performance degradation and workload increases (physical and/or cognitive) should be investigated. Stakeholders should be involved to help shape how the resulting technology should highlight when workload levels reach limits that degrade human cognition and performance, so that they information can be used during design, development, testing, and evaluation of operational and training systems in order to support upgrade activities and decision making with objective data.

The measurement tool should also take into account the ways cognitive work changes as expertise develops [2]. Workload measures are frequently sought when a new system or technology is introduced or an existing system is changed. Because operators will have the opportunity to adapt to the system or technology over time, decision makers have yet another reason to discount or doubt the value of the workload measure. Effective cognitive workload assessment tools would take advantage of what is known about expertise acquisition to make sound predictions about the potential for operators in a given domain, with training and practice, to achieve a manageable level of cognitive workload.

This capability has a range of applicability from aircrew systems through investigation of life support systems, to training systems development and effectiveness evaluations. As we pipe more and more data into our control centers, aircraft cockpits, and automobile consoles, it becomes more and more critical that we be able to determine when workload affects the operator's ability to compensate safely.

PHASE I: Demonstrate feasibility, utility and effectiveness of proposed approach as, discussed in the Description section, for assessing cognitive workload and impacts to the degradation of cognition and performance.

PHASE II: Develop a prototype of the absolute cognitive workload technology and refine the underlying cognitive workload assessment method based on research across a range of fast-paced and high-consequence work domains. At least one validation study should evaluate the ability of the technology to make reliable and useful predictions about workload.

PHASE III DUAL USE APPLICATIONS: The company should support the Navy in transitioning by integrate the workload assessment technology into research, development, test and evaluation facilities and programs that support acquisition and training. Demonstrate cost reduction and benefits to the quality of systems and technology enhancements. This technology can be used to benefit systems development and technology upgrades across military, department of defense, and civilian sectors. For example, the Federal Aviation Administration's (FAA's) NextGen initiative to upgrade and enhance National Airspace System (NAS) operations, in particular, could benefit from improved workload assessment methods and technologies. The resulting technology will benefit programs by supporting optimization of designs where workload is known to be high and may benefit from automation, artificial intelligence, or enhanced human machine interfaces, as well as those where consequences of degraded performance are high.

REFERENCES:
1. Bi, S., & Salvendy, G. (1994). Analytical modeling and expericognitive study of human workload in scheduling of advanced manufacturing systems. International Journal of Human Factors in Manufacturing, 4(2), 205-234

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7. Hollnagel, E., & Woods, D. (2005). Joint cognitive systems: Foundations of cognitive systems engineering. Boca Raton, FL: CRC Press

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9. Patterson, E. & Miller, J. (2010). Macrocognition metrics and scenarios: design and evaluation for real-world teams. Aldershot, UK: Ashgate.

10. Pharmer, J. A., Paulsen, M., & Alicia, T. J. (2011) Validating Environmental Stressor Algorithms for Human Performance Models. Human Systems Integration Symposium. https://www.navalengineers.org/ProceedingsDocs/HSIS2011/Papers/Pharmer.pdf

11. Wickens, C. D. (2008). Multiple resources and mental workload. The Journal of the Human Factors and Ergonomics Society, 50(3), 449-455. http://www.researchgate.net/profile/Christopher_Wickens/publication/23157812_Multiple_Resources_and_Mental_Workloa

12. Wierwille, W. & Eggemeier, F. (1993). Recommendations for cognitive workload measurement in a test and evaluation environment. Human Factors, 35(2), 263-281

13. Woods, D. (2005). Generic support requirements for cognitive work: laws that govern cognitive work in action. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting (pp. 317-321). Thousand Oaks, CA: SAGE Publications

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KEYWORDS: test and evaluation; performance assessment; human-in-the-loop

TPOC-1: 407-380-4773

TPOC-2: 407-380-4528

Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T003 TITLE: Innovative Multi-scale/Multi-physics based Tool for Predicting Fatigue Crack Initiation and Propagation in Aircraft Structural Components using Phase Field Model Technique

TECHNOLOGY AREA(S): Air Platform, Space Platforms

ACQUISITION PROGRAM: PMA-299, H60 Helicopter Program

OBJECTIVE: Develop innovative Phase Field Model (PFM) within numerical framework of Isogeometric Analysis (IGA) for metallic materials subjected to fatigue loading to predict 3D crack topology under complex service loading situations.

DESCRIPTION: Fatigue cracks initiate and grow in complex stress fields in aircraft components subjected to service loadings, exhibiting the 3D nature of the problem. There are no consistent and apparent criteria for many aspects of fatigue crack growth spanning from micro to macro levels. Simulations of a fatigue crack, embedded within a grain or across several grains, require estimates of crack front behavior and an algorithm for growth considering crack size, shape, microstructure and grain boundaries. The challenges associated with modeling fatigue cracks growth stems from the inherent complexity of interaction between material's microstructure and cracks, whether transgranular or intergranular type cracks. One of the main challenges is the numerical modeling of evolution of discontinuities such as cracks in the continuum medium. Although numerical approaches such as Finite Element Method (FEM) and Boundary Element Method (BEM) and their variants exist to evaluate crack propagation, they need complex re-meshing operations and have other difficulties in studying cracks at microstructural level. Therefore, a model that can appropriately address the underlying mechanisms of crack initiation, propagation, and its interaction with material's microstructure such as grain boundaries is highly desirable.

Recently, the phase field method has emerged as a powerful method to simulate crack propagation. The method automatically regularizes stress singularities by introducing a smoothly varying scalar field that distinguishes between "intact" and "broken" phases of the material and can also be interpreted as a phenomenological measure of damage. The phase field model is formulated as coupled dynamical equations for the phase and displacement fields that are derived variationally from an energy function with both elastic strain and surface energy contributions. Phase field equations incorporate both the short scale physics of materials failure and macroscopic elasticity. In addition, these equations can be simulated on parallel computer architecture to describe geometrically complex dynamical phenomenon such as crack nucleation, crack kinking and branching, and crack front segmentation in three dimensions. One of the main advantages of PFM is that there are no ad hoc rules or conditions needed to determine crack nucleation, propagation, or bifurcation. Another advantage is that the solution from the PFM method can be obtained by finite element and isogeometric analysis (IGA) discretization methods which make it more appealing from the modeling perspective. Isogeometric analysis provides an efficient, smooth basis for computation. Once the problem is recast in terms of isogeometric analysis framework, the additional smoothness requirements are met with minimal computational cost.

As such, computational models are desired for fatigue crack nucleation and propagation that alleviates the complexity of re-meshing and can track the crack tip in complex microstructures, while at the same time can be efficiently implemented in an efficient computational framework. The phase field model technique in conjunction with isogeometric analysis that utilizes the geometric model, can provide the solution which does not require any criteria for crack initiation and propagation under random spectrum loading including environmental effects.

Phase field model development will be required in order to link spatial and temporal evolution of complex crack patterns to the external applied load by utilizing finite element and iso-geometric analysis (IGA) discretization methods. Starting with an initial 2D analysis, the PFM model has to describe the complex phenomena of 3D crack evolution at a microscale as well as the final fracture at the macroscale. The proposed PFM model may include an appropriate plasticity model to study load interactions occurring in complicated loading situations such as variable amplitude loading. Finite element based numerical implementations of the PFM crack propagation under dynamic loading is desirable. Furthermore, the application of PFM to dynamic ductile fracture needs to be further explored, addressing the limitations and assumptions and enhancements as needed.

Collaboration with an original equipment manufacturer (OEM) in all phases is encouraged, but not required, to assist in defining aircraft integration and commercialization requirements.

PHASE I: Determine the feasibility to develop a PFM modeling technique based on finite element and isogeometric analysis (IGA) discretization methods to model complex 3D crack patterns under service loading at micro scale as well as the final fracture at the macroscale. Develop guidelines for defining the free energy function in terms of the order parameter, elastic and plastic strains, etc., to be used in the PFM. Show the capability of the PFM model in modeling crack interaction with material's microstructure such as grain boundary.

PHASE II: Based on Phase I effort the small business will continue to address and develop the PFM modeling capability in a systematic way to move from a qualitative visualization to a quantitative assessment. Show how the PFM model can predict 3D crack nucleation, propagation, branching and interaction under complex load spectrum. Test and validate the model by closely following crack propagation test data set for complex loading.

PHASE III DUAL USE APPLICATIONS: Integrate the developed fatigue crack initiation and propagation analysis package into processes at the FRC's, and potentially work in conjunction with the original equipment manufacturers for analysis of repairs and new designs. Methods and techniques developed can be folded into commercial software package for broad use in a wide variety of industrial applications in estimating the life of a variety of safety critical structures.

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KEYWORDS: Crack Growth; Multi Scale Modeling; Isogeometric; Phase Field Method; Crack Initiation; Finite Element Analysis

TPOC-1:   301-342-0297

TPOC-2:   301-757-2427

Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T004   TITLE: Quantifying Uncertainty in the Mechanical Performance of Additively Manufactured Parts Due to Material and Process Variation

TECHNOLOGY AREA(S): Materials/Processes

ACQUISITION PROGRAM: PMA-280 Program Office

OBJECTIVE: Quantify the effect of variations in process characteristics on the mechanical performance of additively manufactured (AM) parts, and develop a procedure for mitigating these effects within statistical bounds using Integrated Computational Materials Engineering (ICME) framework.

DESCRIPTION: The certification of additively manufactured parts requires that mechanical performance be quantified to a minimum of B-basis allowable (90% of the population values are expected to equal or exceed that strength value with 95% confidence). Additional considerations will be necessary based on the artifacts reliability and functionality, for example in the determination that the part is a single point of failure will elevate this to an A-basis allowable (at least 99% of the population values is expected to equal or exceed this tolerance bound with 95% confidence). To achieve this, the Navy requires quantitative uncertainty assessment methods to predict, with a known level of confidence, the microstructural and mechanical property outcomes for a specific material, machine, geometry, and post-processing combination involved in an AM system.

A material used in an AM process undergoes several complex, transient, and interacting physical phenomena, including: heat and mass transfer, material phase transformation, and free-surface fluid flow. These phenomena significantly affect the material property distribution of a built component. AM post-processing techniques, such as stress relief and hot isostatic pressing (HIP), further alter the distribution of material properties obtained during the deposition process. Therefore, approaches such as ICME are needed to link the time and length scales of the occurring physical phenomena. These multi-scale simulations should predict: the interdependencies at play among deposition process; the resulting material micro-structure; local mechanical properties; the overall component performance; and the effects of post-processing.

The challenge inherent to AM processes is the mechanical property distributions within a specific part which are functions of stochastic variables. Knowing the exact machine and material state at any point in time has inherent uncertainties in the form of aleatoric and epistemic uncertainties. The main sources of aleatory uncertainty in AM systems include material characteristics (e.g. chemical composition, powder size distribution, roundness) and process parameters (e.g. laser scan speed, power density, and delay time). There are also several sources of epistemic uncertainty present in AM such as powder local compaction density, friction between powder particles and so on. To effectively model this highly complex and random process, powerful stochastic modeling techniques such as in reference [1] are needed, connecting material and processing characteristics to microstructure distribution, mechanical property distribution, and mechanical performance.

The challenge is to determine how multiple sources of uncertainties are propagated in a model developed specifically for an AM process, such as in reference [2], and then how to quantify the uncertainty of the resulting material properties and microstructure to predict desired performance in probabilistic terms. Keeping this challenge in mind, the topic requires: a comprehensive approach [3] to quantify the uncertainties of material and process model parameters; recommendations on minimizing both material and process uncertainties in production; and suggestions for acceptance metrics/criteria and tolerances for decision making.

One approach could be the use of physics based models or ICME tools to run simulations of the AM process to narrow down the uncertainty.

PHASE I: Develop innovative concepts, processing methodologies, and/or tools that support the goal of rapidly quantifying the mechanical performance of additively manufactured metallic parts. Additionally, develop a novel approach to address the sources of uncertainty in the AM process as well as propose a method to account for these uncertainties. Demonstrate the ability of the proposed method by focusing on a single AM process and single alloy (e.g., laser powder bed and Ti-6Al-4V).

PHASE II: Further develop and finalize the concept, processing methodology and/or tool from Phase I for metallic materials relevant to naval aviation. Design and perform experiments to validate the approach and to quantify uncertainty in standard test methods for determining material and process characteristics. Develop an uncertainty analysis method to assess the impact of parameter/model uncertainties on the output of metallic AM parts certification approach.

PHASE III DUAL USE APPLICATIONS: Deliver a capability to provide rapid uncertainty quantification for the mechanical performance of a broad range of additively manufactured metallic parts. These new approaches can be used to accelerate the FAA certification process as well as the NAVAIR process. Fast uncertainty quantification will promote a wider acceptance of AM technology within both the military and commercial sector.

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KEYWORDS: Additive Manufacturing; Modeling; Metallic; Microstructure; Materials Processing; Quantification

TPOC-1: 301-342-5169

TPOC-2: 301-342-9389

Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T005 TITLE: Air Cycle Machine Low Friction, Medium Temperature, Foil Bearing Coating

TECHNOLOGY AREA(S): Air Platform, Materials/Processes

ACQUISITION PROGRAM: PMA-265, F/A-18 Program Office

OBJECTIVE: Design and develop a durable low friction safe coating, and an application method, for use on foil bearings used in aircraft air cycle subsystem turbomachines.

DESCRIPTION: In many aircraft, air cycle machines (ACM) are used to provide cooling, cabin pressurization, and as part of the system that provides breathing gas to the pilot oxygen system. The foil (air) bearings in the aircraft ACM use coatings to reduce friction during transient conditions such as starts and stops and inadvertent contacts, when hydrodynamic forces are insufficient to support bearing loads. Properties that are desirable in these systems are high lubricity (low friction) and high durability. Post-failure teardown and analysis of current foil bearing ACMs used in U.S. Navy tactical aircraft shows unacceptable (shaft contacts the bearing base metal) coating wear in the form of off-gassing, erosion, and delamination of the bearing coating. In an effort to improve ACM reliability, an alternative coating that will meet the requirements of air cycle machine foil bearings is needed. The coating should provide a low friction contact surface that will not impede rotation during starts and stops and should be wear resistant to provide a suitably long life (goal is a 6000 operational hour bearing) prior to requiring replacement. The coating must not introduce any toxic or hazardous constituents or byproducts to the airflow over the operating temperature range of the unit and may not require redesign of any component. The air bearings are used to support both axial and radial loads (two different bearings). During operation, there is the potential for impact between the rotating shaft and the bearing surface which can generate short term temperature spikes and higher than normal stresses. The bearings are flexible and provide a limited amount of deflection with known spring rates. The normal operating temperature ranges are 250 to 350 F with spikes estimated to be as high as 1400 F.

The application of the coating to the bearing base metal must not affect the base material (high temperature metal, e.g. Inconel) integrity of the substrate and should be able to sufficiently cover the contact surfaces. The friction between the shaft and the bearing should be minimized to allow for starting of the air cycle machine.

PHASE I: Design and develop an innovative coating material, and a means of applying the coating, which is durable, exhibits low friction, and does not produce any toxic or hazardous constituents or byproducts, especially at temperatures above normal operating temperatures. Demonstrate the feasibility of developed technology through limited testing.

PHASE II: Fully develop the coating designed in Phase I into a durable and low friction bearing surface for use in air bearings for an air cycle machine which will include the application process and formulation of the coating. Demonstrate the prototype coating through verification and validation of coated bearings in a relevant naval environment (TRL 6). The technology required for full scale manufacturing will also be developed and verified that it is feasible.

PHASE III DUAL USE APPLICATIONS: Manufacture actual bearings for testing in air cycle machines and develop life estimates. The target result should be a bearing coating that can be qualified for use in aircraft (F-18 or F-35). Complete the transition from TRL 6 to TRL 8 or higher. The developed technology may have applications in coatings for tools, sports equipment, internal combustion engine coatings, rolling element bearings, and kitchen utensils.

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KEYWORDS: foil bearing; air cycle machine; coating; low friction; Turbomachinery; non toxic

TPOC-1: 301-342-8964

Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T006 TITLE: Novel, High-Efficiency, Light-weight, Flexible Solar Cells as Electrical Power Generation Source

TECHNOLOGY AREA(S): Materials/Processes, Sensors, Space Platforms

ACQUISITION PROGRAM: PMA 262, Persistent Maritime Unmanned Aircraft Systems

OBJECTIVE: Develop a capability for high power conversion efficiency and stability in organic solar cells based on novel materials and an innovative device to create a reliable power generation source for naval aviation applications.

DESCRIPTION: Solar cells convert sunlight energy into usable electric power due to the photovoltaic effect. The key measure of performance of solar cells is power conversion efficiency, which is defined as the ratio of energy output from the solar cell to the input energy incident on it from the sun. Current semiconductor based solar cells (Silicon, GaAs) demonstrate high efficiencies (up to 50%). These solar cells are manufactured by complex capital and labor intensive processes, which, in combination with the scarcity of source materials availability, limits the ability to reduce cost, limits scale up, and prevents widespread applications.

Plastic cells, otherwise known as organic solar cells, use conducting polymers or inorganic materials for light absorption and charge transport to produce electric power. They allow the use of abundant, non-toxic materials that can be built on flexible substrates, and represent transformative technology. The conformal, light-weight, flexible feature of such plastic cells producing electric power reliably is attractive for naval applications, especially for unmanned aircraft systems (UAS). However, novel material discoveries in conjunction with innovative device designs, demonstrating high efficiencies are needed to integrate such solar cells into target applications.

Current UASs are designed to provide tactical intelligence, surveillance and reconnaissance (ISR) capabilities that enable mission planning and execution. The real time ISR needs force constraints on space, weight, and power (aka SWaP), and most importantly, flight endurance of the UAS. A limiting factor for successful mission performance is the lack of reliable high efficiency power generation systems with high power and energy densities. Though, lithium-ion battery technology can act as such a power source, it is limited by safety concerns as well as a limited time of use as a power source, requiring frequent recharging. There is a need for a source that generates power on a continuous basis to enable increased duration missions for the UAS.

Recent advancements where photovoltaic function in solar cells has been demonstrated using the perovskite class of materials acting as light-harvesting layers in hybrid organic-inorganic configuration has significantly improved efficiencies from 3.8% to about 20%. The advancement is achieved by fine tuning the material properties such as charge mobility, band gap, and energy levels to maximize photo voltage, light absorption, and charge carrier transport, respectively [2-5]. A notable feature is that such solar cells are reported to have exhibited steady performance over significant periods of time without degradation.

A key hurdle for the implementation of these thin film solar cell technologies is the prohibitive cost ($/Watt basis). Scalability is another concern, since conventional silicon solar cell manufacturing processes are harder to scale up. There is a need for the thin film solar cells to be manufactured by a low cost process that is not only scalable, but also leverages well-developed industry manufacturing methods [6-10]. An example of efficient, low cost manufacturing is the roll to roll (R2R) processes on large area flexible substrates, used in the electronic industry. To reduce manufacturing cost up to 50%, devices need to be built using low temperature process steps using large area coating or printing methods.

The objective is to develop high-efficiency, non-silicon based plastic cells with novel materials, novel device designs, innovative architectures, and to demonstrate the cells as reliable sources of power generation as applicable to naval aircraft [11-13]. Novel tandem cell designs with heterojunction device structures, which facilitate the absorption of significant portion of the solar spectrum to boost the overall efficiency, can be part of the invention. In addition, manufacturing processes that hold promise in terms of scalability, reduced process cost, and complexity, while retaining structural integrity and providing stable performance over an extended period of time are required.

The generated electric power should be stored using energy storage technologies (EST), such as batteries and capacitors with high energy density storage capability to improve the operational effectiveness when solar irradiation is not available. Offerors must include EST as part of the prototype demonstration. Novel EST designs where devices are an integral part of the air vehicle structure can be a part of the innovation.

PHASE I: Develop concept for solar cell devices incorporating novel materials and advanced designs to achieve high-efficiencies (= 20%) at standard air mass (AM) 1.5 conditions. Demonstrate the feasibility and stability of the conceptual solar cells through analytical methods and or limited testing. Compare results with a baseline control (= 500 hrs).

PHASE II: Fully develop the concept conceived during Phase I into prototypes of solar panels with cells and modules and perform detailed characterizations such as carrier lifetime, electroluminescence, and current-voltage measurements as a function of temperature to optimize spectral response and extend stability to enable the solar cells last for several years. Apply modeling and simulation tools as necessary. Demonstrate innovation to adapt scalable, robust manufacturing processes to produce flexible solar cells. Independent verification of the efficiency is strongly recommended.

PHASE III DUAL USE APPLICATIONS: Perform verification and validation. Demonstrate the functionality of conformal, light-weight solar panels that meets the electrical power needs of aircraft in a safe and effective manner in an operational environment. Transition the technology to appropriate Navy platforms (ex. UAS systems), obtain flight certification, and commercialize the technology. The high power conversion efficiency combining with stability of the solar cells act as a reliable power source for naval aircraft. The flexible nature allows conformal wrap and integration into an air vehicle without any significant weight penalties. Improvements made under this topic will tremendously benefit the commercial aviation, consumer, and automobile markets including the recent FAA approval for civilian use of drones.

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KEYWORDS: Solar Cells; Plastic Cells; Material Innovation; High-Efficiency and Conformal; Reliable Power Source; Unmanned Aircraft Systems

TPOC-1: 301-342-0365

TPOC-2: 812-854-4082

Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T007 TITLE: Optimized High Performance Stainless Steel Powder for Selective Laser Melting Additive Manufacturing (AM)

TECHNOLOGY AREA(S): Air Platform, Materials/Processes

ACQUISITION PROGRAM: PMA-261 H-53 Helicopter Program Office

OBJECTIVE: Develop a stainless steel powder with advanced material characteristics to improve processability, part quality, and performance using an integrated computational materials engineering (ICME) framework to enable the use of selective laser melting (SLM) AM for the replacement, and future design of stainless steel components used in Naval aviation.

DESCRIPTION: Additive manufacturing (AM) has the potential to revolutionize part design and acquisition for the Navy. Further development is needed before AM is accepted for the production of structural components and current efforts to advance AM often overlook its foundation: the material. For many Navy applications, this material is typically a metallic powder used in a powder bed AM system. Current state-of-the-art metal powders, in particular stainless steel powders, have been found to be incapable of producing parts that meet the performance requirements for Naval applications without extensive post processing. Research has shown that powder characteristics like particle size, shape, and distribution; packing density; conductivity; and chemical composition have significant impact on a part's microstructure which contributes to producing unsatisfactory parts. These properties have also been found to vary widely from supplier to supplier due to different powder processing techniques and self-established specifications. As such, many AM machine manufacturers impose limits on the powders they allow to be used in their machines forcing their consumers to purchase only the manufacturer's specified powder or risk voiding their warranty.

A stainless steel powder with advanced material characteristics to improve processability, part quality, and performance for use in SLM AM for the replacement, and future design, of stainless steel components used in Naval aviation is sought. An ICME framework should be used to optimize the powder characteristics (e.g. compositional ranges, interstitial content, morphology, and conductivity.) 17-4PH alloy parts are carefully heat treated in order to obtain optimal properties by precipitating a 2nd phase strengthening. Similarly the powder alloy must be capable of achieving optimal properties via thermal processing. The powder must promote processability (e.g. size and shape consistency; high conductivity and packing density; wide melting range; reusability; and able to be used in a variety of powder bed AM machines) and produce as-built parts that exhibit quality (e.g. geometric accuracy and surface finish) and performance (e.g. strength, ductility, hardness, and fracture toughness) equivalent to or better than conventionally built 17-4PH parts.

PHASE I: Develop a stainless steel powder, which when used in SLM AM results in equivalent or better material properties as compared to traditionally manufactured 17-4PH. Design the selected powder using ICME tools. Establish feasibility of the developed powder by fabricating coupons and generating limited test data such as static and fatigue properties for comparison.

PHASE II: Optimize the metal powder characteristics through an iterative approach that includes modeling, fabrication, and testing of prototype parts. Initiate the development of the material properties database for the optimized design, through the fabrication and testing of a small, but complex shaped component. Demonstrate compatibility with a variety of laser melting machines.

PHASE III DUAL USE APPLICATIONS: Fully develop the design allowable database for the material. Demonstrate and validate the performance of the new material through component testing in a service environment. Transition the newly developed, optimized powder for use in the fabrication of Navy and commercial stainless steel aircraft parts through SLM AM. Stainless steel is used in a wide variety of industries (e.g. aerospace, automotive, energy, construction, and medical.) The desired AM-tailored stainless steel powder would provide these industries with an opportunity to incorporate SLM AM to produce high-performance, complex parts. This effort would also produce the groundwork needed to develop additional AM-tailored materials for other commercial applications.

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KEYWORDS: Cost Reduction; Metal Additive Manufacturing; Part Quality; Stainless Steel; Powder Optimization; Material Characterization

TPOC-1: 301-342-8511

TPOC-2: 301-757-5524

Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T008 TITLE: Novel Separator Materials for Achieving High Energy/Power Density, Safe, Long-Lasting Lithium-ion Batteries for Navy Aircraft Applications.

TECHNOLOGY AREA(S): Electronics, Materials/Processes, Sensors

ACQUISITION PROGRAM: Navy and Marine Corps Small Tactical Unmanned Air Systems, PMA 263

OBJECTIVE: Develop and demonstrate novel, tailored, designer separator materials with optimized properties to maximize lithium-ion cell/battery performance, life, safety and reliability.

DESCRIPTION: A typical lithium-ion cell consists of a positive electrode, such as $LiFePO_4$ coated on an aluminum current collector, and a negative electrode, such as carbon coated on a copper foil current collector. The electrodes are separated by a porous plastic film (separator) soaked by an electrolyte liquid. The key function of the separator is to prevent electrical contact between the positive and negative electrode, thereby preventing electrical shorting. The separator has an additional role as a charge-carrier facilitator.

During discharge, for example, the anode supplies Li^+ ions to the separator and electrons to the external circuit. The positive Li-ions are inserted into the cathode electrode and are charge compensated by negatively charged electrons in the external circuit, resulting in usable electrical power of the cell/battery. Thus, the separator has to allow ions to transport, but block the flow of electrons. In other words, functionally the separator must be a good ionic conductor, but be a poor electronic conductor.

Separator materials play an important role in achieving high energy and power density and ensure the safety of the battery [1-2]. Cells with high resistance separators perform poorly during high rate discharge and contribute to an increase in charge time. Larger pore sizes of the separator will allow more shorts during high-temperature storage; smaller pore sizes impact cycle life at low temperature. Thinner separators contribute to increasing the capacity by virtue of lower resistance. However, if they are too thin, there may not be enough required mechanical strength. The separator is exposed to volatile, flammable, organic, corrosive electrolyte liquid and operate in a reducing and oxidizing environment. Thus, the designer separator materials should have low resistance, uniform pore structure, and superior oxidation-resistance properties.

In case of rapid internal increase due to electrical (overcharge, short circuit) or mechanical (nail penetration, crush) abuse, the separator has to be shut down, which requires the process to be irreversible to ensure safety [3]. The shutdown prevents thermal runaway events such as those that has contributed to failure of the commercial airliner batteries. The high-temperature melt integrity feature will preserve the safety of the cell during extended overcharge or exposure to higher temperature. The separator must block the lithium-metal dendrite from penetrating through and causing internal shorts. It is to be noted that dendrite growth leading to puncturing the separator and creating internal shorts is one of the major root cause failures of fielded Li-ion batteries. Thus, separators with excellent shut-down features combined with structural integrity are vital to achieving thermal stability and ensuring safe operation of the cell/battery. Overall, the separator and its material properties have a significant impact on the aspects of reliability, safety, high-performance, and longevity of the Li-ion battery.

The majority of the separators used in Li-ion batteries, however, are derived from spin-off technologies and are not specifically developed or optimized for Li-ion batteries. The only advantage is that they are produced in large volume at a relatively low cost. The need is the development of tailor-made novel separator materials with the required chemical, mechanical, and electrochemical properties that will improve the performance, longevity, and most importantly, improve safety without adversely affecting cost.

The goal of the effort is to develop novel separator materials tailored for Li-ion batteries with the following features influencing the design considerations: electronic insulator/high ionic conductivity, physical strength, chemical resistance, mechanical stability, wettability, pore size optimization, dendrite migration prevention, impurity particulate reduction, rapid shut-down, and thermal stability [4-7].

PHASE I: Develop and demonstrate novel separator materials with optimum properties tailored for Li-ion battery applications as proof of concept. Demonstrate feasibility through analytical methods and construct a Li-ion cell for comparison with a baseline control.

PHASE II: Fully develop the concept into a safe, high-performance Li-ion battery prototype by integrating the innovative separator materials in cells/modules/pack, to demonstrate the gain and response to failure modes in a lab environment.

PHASE III DUAL USE APPLICATIONS: Demonstrate the functionality of the Li-ion battery product that meets the electrical needs of aircraft in a safe and effective manner in an operational environment. Obtain flight certification and transition the representative technology to appropriate Navy platforms (Ex. UAS, F/A-18E/F, F-35) and commercialize. Due to ~ 1/3 weight and ~ 3X energy in comparison to current lead-acid batteries, Li-ion batteries have become the energy storage system of choice. The performance improvement combined with safety is very attractive for Navy aircraft applications. Improvements made under this topic will tremendously benefit commercial aviation, consumer, and automobile markets.

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KEYWORDS: Li-ion battery; Safety System; High energy density; Dendrites; Separator; High Power Density

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Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T009 TITLE: Medium Voltage Direct Current (MVDC) Fault Detection, Localization, and Isolation

TECHNOLOGY AREA(S): Ground/Sea Vehicles

ACQUISITION PROGRAM: FNC Efficient and Power Dense Architecture and Components; PMS 320

OBJECTIVE: Develop an affordable method for detecting, localizing, and isolating faults in a Medium Voltage Direct Current (MVDC) zonal electrical power system for naval warships.

DESCRIPTION: MVDC electrical distribution systems are being considered for future naval combatants to affordably achieve power and energy density sufficient to successfully integrate advanced high power electric weapon systems and electric propulsion. By reducing the amount of power conversion and energy storage required as compared to an AC system, MVDC systems offer the opportunity to incorporate electric weapons and high power sensors in surface combatants under 10,000 MT. Since the surface combatant following the DDG 51 class is anticipated to be below 10,000 MT, MVDC will enable these ships to have potentially game changing military capability by employing advanced electric weapons and high power sensors. An important enabler to an MVDC system is an affordable method to detect, localize, and isolate faults on the MVDC bus. Additional details on the overall application of MVDC to shipboard power systems are described in reference 3. One of the key technologies needed for a reasonably priced MVDC system is an affordable (equal to or less than cost of a comparable AC system), reliable method and associated hardware to detect, localize, and isolate faults on the MVDC bus while still maintaining power of the requisite Quality of Service to individual loads.

The use in MVDC power systems of traditional electromechanical circuit breakers common in AC systems is complicated by the need to extinguish the arc once the circuit breaker contactors open. In an AC circuit breaker, the natural zero crossing of the current waveform provides a mechanism for extinguishing the arc and establishing a voltage barrier to prevent the arc from re-striking. DC circuit breakers cannot take advantage of the current zero crossing. Hence, electromechanical circuit breakers are limited in the amount of DC current they can interrupt. Several manufacturers are developing hybrid DC circuit breakers that use semiconductors to shunt the current when the electro-mechanical breaker opens, thereby eliminating the arc. Although these hybrid DC circuit breakers are anticipated to work, they cost more than traditional AC breakers and will require more volume. Alternate solutions to MVDC circuit breakers (capable of interrupting greater than the rated steady-state current up to 4,000 amps with potential growth to 8,000 amps) are sought that will reduce cost by at least 20%, improve power and energy density by at least 20%, of the overall power system as compared to an equivalent AC power system. Solutions shall not have a significant negative impact on the overall power system energy efficiency.

Since power electronic rectifiers create MVDC, fault currents can be limited by controlling the power electronic rectifiers, enabling alternate strategies such as employing less expensive disconnect switches to reconfigure the plant once the power electronics have halted current flow (requiring however, zonal energy storage to power loads while the fault is cleared on the MVDC bus). The challenge confronting system designers of a MVDC system is to understand the behavior of the MVDC system when upstream rectifiers limit current and interrupt current and the rectifiers' criteria for doing so.

Localization of faults on an MVDC bus must consider the bi-directional nature of power flow of a zonal system. In AC zonal systems, a Multifunction Monitor (MFM) assists in the localization of faults. An analogous component may or may not be needed for an MVDC system.

Future MVDC systems are anticipated to operate between 6 kV and 18 kV. The grounding scheme for the MVDC system has not been established. Nominal rated bus current are anticipated to initially range up to 4,000 amps; with potential growth to 8,000 amps.

PHASE I: In Phase I, the company must provide a concept for an affordable method for fault detection, localization, and isolation on a Medium Voltage DC bus. This concept must include a description of the allocation of functionality among power conversion equipment, power distribution equipment, system controls, and other power system elements. The company will provide evidence that the proposed concept will likely prove more affordable and be more energy power dense than an analogous AC distribution system by 20%. The company shall demonstrate the feasibility of their concept through modeling and simulation. The company should identify technical risks of their concept. The Phase I Option, if awarded, will include the initial design layout and a capabilities description to build into Phase II.

PHASE II: Based on the results of Phase I efforts and the Phase II Phase II Statement of Work (SOW), the company shall develop a reduced scale prototype system to address the technical risks of their concepts. The company shall develop draft specifications for the different elements of the concept. At a minimum, the reduced scale prototype system shall consist of multiple MVDC sources of power, at least one MVDC load, and multiple ship service zones. The company shall conduct testing of the reduced scale prototype system. The reduced scale prototype system testing shall address technical risks, validate the draft specifications, and demonstrate the functionality of the overall concept in detecting, localizing, and isolating faults.

PHASE III DUAL USE APPLICATIONS: The company shall support the Navy in transitioning the technology to Navy use. The company shall develop specifications and first articles for concept unique elements (such as an MVDC, MFM, or MVDC circuit breaker) and specifications for other concept elements (such as power conversion equipment) which must have specific functionality to implement the fault detection, localization, and isolation concept. The technology will be installed on future surface combatants following the end of production of the DDG 51 class. An affordable fault detection, localization, and isolation method for MVDC systems has many potential commercial applications to include commercial ships, industrial facilities, server farms, photovoltaic farms, and wind farms.

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KEYWORDS: MVDC fault detection; MVDC fault localization; MVDC fault isolation; Power Electronics Fault Current Control; MVDC electrical distribution; zonal electrical power system

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N16A-T010 TITLE: Additive Manufacturing for Microwave Vacuum Electron Device Cost Reduction

TECHNOLOGY AREA(S): Battlespace, Electronics, Sensors

ACQUISITION PROGRAM: PEO IWS 2.0, SPY-1 Radar

OBJECTIVE: Develop additive manufacturing for key microwave vacuum device components that meets on-demand, flexible, and affordable manufacturing requirements.

DESCRIPTION: A majority of existing Navy radar, fire control, and electronic warfare (EW) systems, as well as some communications systems, employ microwave vacuum electron devices (for example, microwave tubes). Solid-state retrofitting of these systems is expensive and simply cannot be done in many cases. Therefore, to support these legacy systems, microwave tubes will remain in the Navy inventory for decades to come, although in slowly decreasing quantities. Microwave tubes offer unmatched performance but are expensive and the decreasing demand increases their per-unit cost. This is largely due to sporadic manufacturing, often in quantities insufficient to support continuous production. It is common for procurements of microwave tubes to involve quantities of a few dozen or less. The discontinuous and batch nature of production then ripples through the manufacturing supply chain, resulting in long lead times and added expense for key piece-parts.

Even under the best of circumstances, manufacturing of microwave tubes is a labor-intensive process requiring multiple steps that typically combine unique materials and manufacturing processes. For example, parts and sub-assemblies are typically brazed in sequential steps with the lowest level assembly receiving the highest braze temperature so that the part can survive succeeding braze cycles at progressively lower temperatures. The body of the tube must be impermeable to provide a perfect vacuum. Ceramic to metal seals are the industry norm with oxygen-free high-conductivity (OFHC) copper and high purity alumina predominating. Interior sub-assemblies often combine multiple, specialty metals (including refractory metals) which present unique manufacturing challenges (Ref. 1 and 2).

Furthermore, microwave tube manufacturing has inherent design and quality requirements specific to the industry. For example, the heat load encountered in most tubes presents not only thermal management challenges, but metal-to-metal and metal-to-ceramic joints must be designed to compensate for differing coefficients of thermal expansion. Ceramics often require complicated shapes, such as corrugation (to inhibit high voltage breakdown) and typically undergo complex plating processes in preparation for joining. Throughout the manufacturing process, the governing requirement is vacuum integrity. Materials selection, design, handling, machining, and fabrication are all performed with an eye to the final vacuum processing step that ultimately determines production yield, so crucial to overall cost.

The advent of additive manufacturing (commonly known as 3D printing) offers a possible solution to the expensive and discontinuous nature of microwave tube manufacturing, as well as offering potential manufacturing advantages not available with traditional machining (Ref. 3). The ability to produce parts as needed and reduce the waste of expensive materials would be a boon to the industry. Even greater advantage could be gained from the single-step production of complicated structures (such as resonant cavities) that typically require the brazing of multiple parts. Some relevant progress in this area has been made. For example, ceramic elements for microwave circuits (Ref. 4) and a proof-of-concept slow-wave structure have been recently fabricated (Ref. 3). However, the stringent requirements (e.g. tight mechanical tolerance, low surface roughness, and high-vacuum compatibility) particular to microwave tube production have so far inhibited the broad adoption of additive manufacturing methods by the industry. Consequently, innovative additive manufacturing technologies for microwave tube cost reduction are desired. Target values of 40%-70% cost reduction are considered reasonable (as compared to conventional machining of the same part), depending on the complexity of the parts chosen for demonstration.

The Navy needs an additive manufacturing method that must meet two key requirements. First, it must produce vacuum quality parts. Any process that leaves residual solvents, oils, binders, sacrificial materials, or other contaminants (metal or organic) which cannot be removed by cleaning or heat treatment (bake out) are useless to the industry. Likewise, the parts cannot be porous such that they trap residual gas. Second, it must have an acceptable process to produce parts of high mechanical accuracy, as many microwave tube circuits have critical dimensional tolerances approximately one thousandth of an inch. Other desirable features would include the ability to form parts in more than one metal, the ability to form complicated parts such as hollow cavities that cannot be machined out of one piece, and the ability to plate parts in-place. Desirable technologies for ceramic manufacturing would produce complicated ceramic shapes as well as have the ability to vary the ceramic material in order to produce ceramics with gradually varying loss characteristics. Common to all of these requirements is that the technology must produce parts in the metals and ceramics that are standard to the microwave vacuum devices industry.

This topic serves to increase mission capability by controlling life-cycle cost and reducing delays in the procurement of microwave tubes for critical and widely deployed Navy systems such as SPY-1, SPS-48, SPQ-9B and Nulka. Sustainment of legacy systems is a major challenge and few opportunities exist to introduce cost savings measures. This effort is a basic manufacturing technique that can reduce cost incrementally across many systems. The need for flexible manufacturing techniques will only grow as these legacy systems age and become harder to support. As it is, manufacturers see little incentive to invest in technology to support legacy systems now. However, this technology has broad appeal and is attractive for both existing and new military and commercial products.

PHASE I: The company will develop a concept for innovative additive manufacturing technology for microwave tubes that meets the requirements stated in the topic description. The company will demonstrate the feasibility of their concept in meeting Navy needs and will establish that the concept can be feasibly produced through sample testing, modelling, simulation, and analysis. In the Phase I Option, if awarded, the company will develop a capabilities description and a plan for development and demonstration of the technology in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), the company will develop prototype additive manufacturing techniques and equipment for the production of microwave tube parts consistent with industry material standards and assembly practices as described in the description section. The prototype techniques and equipment will be evaluated to determine their capability in meeting the performance goals defined in the Phase II SOW and the Navy requirements for reduced cost microwave tube manufacturing. Performance will be demonstrated primarily through testing by the small business of industry-representative sample tube parts for mechanical and vacuum integrity over the required range of manufacturing and operating parameters, including braze, bake out, and vacuum exhaust cycles. Testing may be augmented by modeling and analytical methods. Evaluation results will be used to refine and deliver the prototype with an initial design that will meet Navy requirements. The company will prepare a Phase III plan to transition the technology for commercial use and to supply Navy needs.

PHASE III DUAL USE APPLICATIONS: The company will be expected to produce its additive manufacturing technology for microwave tubes and support the processes required for its successful transition to microwave tube-based systems (such as SPY-1) in the Navy. The company will develop and fully document the processes required to integrate the technology for use by industry according to the Phase III development plan. The technology will be evaluated to determine its effectiveness in specialty production of microwave tube parts. This may require the company to license their processes to other manufacturers for actual production. The US domestic microwave tube industry supplies commercial as well as military markets and technologies that reduce process costs typically benefit all product lines. Since this topic seeks to develop a fundamental manufacturing technology and not a specific military application, the potential for commercial application is assured. The potential commercial market is essentially stable, should the technology prove effective.

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KEYWORDS: Vacuum electron device; microwave tubes; microwave vacuum devices; additive manufacturing; 3D printing; refractory metals

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Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T011 TITLE: Fully Encapsulating Dielectrics for Gaseous Helium Cooled Superconducting Power Cables

TECHNOLOGY AREA(S): Ground/Sea Vehicles

ACQUISITION PROGRAM: PMS320, Electric Ships Office; PMS501 Littoral Combat Ship Program Office

OBJECTIVE: Develop an encapsulating medium voltage dielectric material and application process to electrically insulate a high temperature superconducting power cable and end terminations in a gaseous Helium environment.

DESCRIPTION: The Navy is embarking on an aggressive and innovative Power and Energy Program and a Next Generation Integrated Power System (NGIPS) for application on both shore based operations, future surface ships, and underwater vehicles. With the advent of prime mover power generation and high power directed weapons, the Navy is striving to distribute an order of magnitude increase in electrical power without increasing distribution system space and weight or reducing efficiency. The Navy requires cost-effective, innovative technology solutions that fulfill these requirements to ensure that next-generation vessels are able to accomplish their mission.

Future naval power systems are trending toward a fully integrated power system, which leverages installed electrical generation to meet the high power demand of future loads. The electric propulsion loads are within the range of 20-80 MW. The ability to distribute this amount of power in an integrated power system requires increased distribution power densities over what is currently available through conventional copper cabling. High temperature superconductors (HTS) are an ideal candidate for the technology to increase volumetric and gravimetric power distribution densities that will meet the demands of future shipboard power loads.

HTS power cables have matured and proven reliable through land-based programs including multiple in-grid installations (ref. 1 and 4). In addition to providing an excellent cooling medium, the liquid Nitrogen used in these demonstrations provides key dielectric insulation to the cable. Due to safety and logistical requirements for naval applications, liquid Nitrogen is not a viable option for shipboard HTS applications. As an alternative to liquid Nitrogen, the Navy currently uses cryogenically cooled Helium gas to cool HTS degaussing systems (ref. 2). Although Helium is known to have poor dielectric strength, it is not a concern as HTS degaussing is a low voltage system.

For voltage applications approximately 20kV, the weak dielectric strength of Helium warrants dielectric solution that eliminates a Helium path between phases in the HTS cables. This would require the development of a novel dielectric material or process of application to hermetically encapsulate the HTS conductor phases. This novel material or process would support the ability to develop a HTS power cable operating in gaseous Helium at the extreme temperature range of 30-50K. Any solution identified in this topic is required to be applicable to a coaxial DC HTS power cable as well as 3-phase triaxial AC cable. The dielectric material and application process may be extended to a multi-phased HTS power cable termination (ref. 3 and 5). Dielectric strength of a proposed solution should exceed 100 kV/mm, with a breakdown voltage greater than 100kV. The proposed solutions should be able to be applied to each phase of a HTS cable in a manner that does not induce damage to the conductor. This requires the HTS conductor not to exceed a temperature of 160C. The cost of the proposed solution should not exceed $25 per meter per phase of HTS cable.

PHASE I: The company will define and develop a concept for a material and process of applying an encapsulating dielectric material suitable for a 20kVDC HTS power cable and terminations in Helium gas at appropriate density ranges (0.7 kg/m3 to 19.8 kg/m3). The technical feasibility of the proposed concept will be identified and demonstrated through modeling, analysis, and bench top experimentation where appropriate. The solution shall be quantified in terms of dielectric size, weight, and cost. The Phase I final report shall capture the technical feasibility and economic viability for the proposed concept that can be matured further if awarded a Phase II. The Phase I Option, if awarded, should include the initial layout and capabilities description for the material or process to be developed in Phase II.

PHASE II: The company will develop and fabricate a prototype HTS power cable based on the Phase I work and Phase II statement of work (SOW) for demonstration and characterization of key parameters of the dielectric insulation system. Based on lessons learned in Phase II through the prototype demonstration, a substantially complete design of a cable and termination should be completed and delivered to enable Navy qualification testing. The prototype will be evaluated against the predicted benefits identified in Phase I for size, cost, and dielectric strength. The prototype will be delivered at the end of Phase II. A Phase III plan shall be developed to transition the technology to the Navy.

PHASE III DUAL USE APPLICATIONS: The company is expected to support the Navy in transitioning the HTS power cable and termination insulation technology for Navy use. This may include teaming with appropriate industry partners to incorporate the developed dielectric material into a fully qualified power cable for interested acquisition programs including PM501 and PMS320. The company will develop technical data specifications and manuals as needed to support transition of a fully qualified system. The desired electrical power converter has direct applications in commercial power grid, power distribution, electric power conversion, and cryogenic power applications making it broadly applicable to the commercial world.

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KEYWORDS: Dielectric; HTS; superconductivity; integrated power system; high-energy demands for Naval ships; HTS power cable;

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Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T012 TITLE: Medium Voltage Direct Current (MVDC) Grounding System

TECHNOLOGY AREA(S): Ground/Sea Vehicles

ACQUISITION PROGRAM: FNC Efficient and Power Dense Architecture and Components; PMS 320 Electric

OBJECTIVE: Develop an affordable, general method for grounding Medium Voltage Direct Current (MVDC) zonal electrical power systems for naval warships.

DESCRIPTION: MVDC zonal electrical distribution systems are being considered for future naval combatants to affordably achieve power and energy density sufficient to successfully integrate advanced high power electric weapon systems and electric propulsion. Details on the overall application of MVDC to shipboard power systems are described in references 1 and 2. One of the key technologies needed for an MVDC system is an affordable, reliable method as compared to current systems in use and associated hardware to provide a ground reference for an MVDC shipboard power system. The goal for reliability should be a mean time between operational failure of the ground reference system in excess of 30,000 hours. This grounding method must account for multiple sources of MVDC power on the bus; these sources may or may not be online at any one time. These sources will have a power electronics interface with the MVDC bus. The sources of power may include AC generators, transformers, batteries, capacitors, flywheels, and fuel cells.

Desirable attributes of the grounding system include the ability to continue operation with one line to ground fault, the ability to detect and locate line to ground faults, minimizing currents in the hull, and avoiding high line to ground voltages that can stress and reduce the service life of cable insulation. Previous research on grounding systems include those documented in references 4 and 5. To date, of the many possible ways of grounding an MVDC system, a preferred solution for MVDC system grounding has not been established; the Navy has not previously funded industry to develop an MVDC grounding system for a shipboard power system. None of the known existing ways is ideal for the prospective application.

By reducing the amount of power conversion and energy storage required as compared to an AC system, MVDC systems offer the opportunity to incorporate electric weapons and high power sensors in surface combatants under 10,000 MT. Since the surface combatant following the DDG 51 class is anticipated to be below 10,000 MT, MVDC will enable these ships to have potentially game changing military capability by employing advanced electric weapons and high power sensors. An important enabler to an affordable MVDC system is an affordable method to ground the MVDC bus.

PHASE I: In Phase I, the company must provide a concept for the development of a general grounding system for MVDC zonal systems. The grounding system must account for multiple sources of MVDC power on the bus; these sources may or may not be online at any one time. All sources have a power electronics interface with the MVDC bus. The sources of power may include AC generators, transformers, batteries, capacitors, flywheels, and/or fuel cells. The grounding system concept should include the ability to continue operation with one line to ground fault, the ability to detect and locate line to ground faults, minimizing currents in the hull, and avoiding high line to ground voltages that can stress and reduce the service life of cable insulation.

The grounding system concept must include a description of the allocation of functionality among power conversion equipment, power distribution equipment, system controls, and other power system elements. The company must provide evidence that the proposed concept will likely prove more affordable than alternate feasible concepts that the company has considered but not selected. The company shall demonstrate the feasibility of their concept through modeling and simulation. The company shall identify technical risks of their concept. The Phase I Option, if awarded, should include an initial design layout and capabilities description to build a grounding system for MVDC zonal systems prototype in Phase II.

PHASE II: Based on the results of Phase I efforts and the Phase II Statement of Work (SOW), the company shall develop a grounding system for MVDC zonal systems prototype system to address the technical risks of their concepts. The company shall develop draft specifications for the different elements of the concept. At a minimum, the prototype system shall consist of multiple MVDC sources of power, at least one MVDC load, and multiple ship service zones. The company shall conduct testing of the prototype system. Testing shall address the technical risks of the system. The prototype system testing shall validate the draft specifications, and the effectiveness of the grounding system in meeting objectives. The prototype should be delivered at the end of Phase II.

PHASE III DUAL USE APPLICATIONS: The company shall support the Navy in transitioning and integrating the grounding system for MVDC zonal systems technology to Navy use. The company shall develop specifications and first articles for concept unique elements and specifications for other concept elements (such as power conversion equipment and generator rectifiers) which must have specific functionality to implement the grounding system concept. The technology will be installed on future surface combatants following the end of production of the DDG 51 class. An affordable grounding system for MVDC systems has many potential commercial applications to include commercial ships, industrial facilities, server farms, photovoltaic farms and wind farms.

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http://onlinelibrary.wiley.com/doi/10.1111/j.0028-1425.2007.00019.x/abstra

KEYWORDS: MVDC grounding system; MVDC circulating currents; MVDC power systems; MVDC ground fault; MVDC ground fault detection; MVDC ground fault localization

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N16A-T013 TITLE: Cyber Forensic Tool Kit for Machinery Control

TECHNOLOGY AREA(S): Information Systems

ACQUISITION PROGRAM: PEO Ships AM, Acquisition Management

OBJECTIVE: Develop live digital forensics that, at run time, provide a cyber-protection strategy and aid in identification of malfunctions due to malicious and non-malicious events, while ensuring minimal impact on overall system performance.

DESCRIPTION: Shipboard machinery control systems utilize SCADA to monitor and control these systems. Common components of the SCADA systems include human-machine interfaces (HMI), remote terminal units (RTU), input/output devices (I/O), programmable logic controllers (PLC), and communication networks. Digital forensics, consisting of activities associated with the collection and analysis of digital data from various sources, is an essential part of an overall cyber defense strategy both prior to and after a breach of security. For SCADA systems, forensics is not only a vital part of the protection strategy but also can aid in the troubleshooting and identification of non-malicious events that cause the system to malfunction.

A number of unique challenges exist for the forensic analysis of SCADA based systems. Components of a SCADA system are often resource constrained. The opportunity to run forensic resources on devices in the SCADA system depends on the availability of processor, memory, I/O, and other system resources. Many systems running in the field have legacy hardware and lack the computing capabilities of modern hardware systems. The collection of log data in SCADA systems is often inadequate. In particular, immediately following an incident, the collection of log data is critical to being able to re-create the sequence of events leading up to the incident. There are currently no effective methods for capturing the volatile data that exists in the control system registers, cache, memory, routing tables, and temporary file systems. Much of the data that exists in SCADA systems is at the lower layers of the architecture making it more difficult to access. At those layers, sometimes there is such a large amount of data that analysis becomes challenging due to scale and dimensionality.

The solution sought should incorporate data acquisition tools used to support forensics analysis that has minimal impact on the overall operation of the control system. The application must be able to operate as a plug in to an open source forensic tool kit such as Autopsy and have an open system architecture. The application should enable reconstruction and replay of the state of the SCADA system to support incident response. The government will be responsible for scheduling testing and certification of the application in a land based SCADA test facility prior to transition. It is essential that the proposed solution performs live forensics at run time with minimal impact on overall system performance.

PHASE I: The company will investigate and develop an architectural design of a forensic tool set for SCADA including identification of an Application Program Interface (API), for the plug in interface, and functional requirements. The company will define and develop a concept for forensic tools for SCADA that can meet the performance constraints listed in the description. They will perform modeling and simulation to provide initial assessment of concept performance and feasibility. Phase I Option, if awarded, would include the initial layout and capabilities description to build the system in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), the company will develop and demonstrate a prototype forensic tool kit for SCADA based on the interface and functional requirements developed in Phase I. Testing will be conducted in a land based SCADA test facility. The prototype should be delivered at the end of Phase II, ready to be integrated by the government. The Phase II effort will likely require secure access.

PHASE III DUAL USE APPLICATIONS: The company will assist the Navy in transitioning the forensic tool set for SCADA specified in Phase I and prototyped in Phase II to a Navy lab for operational analysis. After Navy laboratory assessment, the company will assist with the integration of the forensic tool kit and demonstrate the complete system shipboard. The company will transition the technology to SCADA. The Cyber forensic tool kit will be applicable to control systems cyber analysis across the government. The cybersecurity tool will also be applicable to all manufacturing, energy production, and oil and mineral processing facility machinery and engine control systems.

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KEYWORDS: Cybersecurity; forensics of cyber-attacks; SCADA; forensic tool set; WeaselBoard; PLC

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N16A-T014 TITLE: Low-cost Thermal Management Technology for Combat Systems Computers

TECHNOLOGY AREA(S): Information Systems

ACQUISITION PROGRAM: PEO IWS 1.0, AEGIS Integrated Combat System.

OBJECTIVE: Develop a modular and scalable cooling technology for electronic computer cabinets and display consoles that do not require forced air or water-to-air cooling.

DESCRIPTION: Navy combat systems integration requires the use of electronics cabinets to support data transfer, processing, and communications across the system and to end users that interface with the system at a console. Common Processing Cabinets (Ref 1) have largely been replaced by Mission Critical Enclosures (MCE) (28" W x 42.42" D x 75" H and 2,000 lbs.) and when fully populated have a 5.0 kW heat load. Other customized processing cabinets can generate as much as 15.0 kW of heat and are physically larger than the MCEs. Electronic cabinets that do not require demineralized water are typically cooled internally with chilled water-to-air cooling systems or through forced air-cooling. These systems require space specific chilled water piping and ventilation air supply and return ducting in the overhead or under a false floor. Similar to electronics cabinets, Common Display System (CDS) consoles used by sailors have had water-cooled designs but have more recently converted to air-cooled designs with heat loads of 0.8 kW. Ship infrastructure for piping and ducting schemes to support thermal management are extensive and costly to change if any sort of reconfiguration of the space is required. Generally, these distributive systems have a great impact on the shipboard system-cooling infrastructure (Ref 2). Other conventional approaches such as using chilled water-cooled water-to-air cabinet cooling systems have concerns with condensation in the enclosures, which require constant draining to avoid spillage within the sensitive electronics.

A modular and scalable cooling system technology that will largely replace the legacy water-to-air cooling systems and forced air-cooling systems is needed so thermal loading can be handled at the source versus in a centralized location that requires complex, expensive, non-reconfigurable distribution systems. Reductions in piping and ducting distribution systems reduces acquisition cost and system weight. Modular cooling will also allow for additional sensors, tactical displays, and consoles to be incorporated into the AEGIS Integrated Combat System because advanced thermal management technology enables a smaller footprint for. An approach that is localized on or near the heat generation source without significant direct shipboard support systems is desired. This system must pass military standards for shock and vibration (Ref 3 and 4). The advanced cooling system should be self-contained and scalable for the anticipated heat loads. Utilization of shipboard support systems such as water should be minimized or eliminated. Scalability to accommodate larger, currently customized, processing cabinets greater than the 5 kW heat load associated with the MCEs is preferred. This would be an attractive enabler to a flexible infrastructure where larger, standardized mission processing packages may be needed for larger and more powerful shipboard radar systems. Legacy radar rooms currently generate as much as 25 kW of heat and the new radar system will be increasing the heat load to these radar rooms to approximately 100 kW or more. Since combat systems in general account for approximately 80% of the total space-cooling load, an advanced thermal management technology could potentially provide space that is more available for the MCEs. The computer room would not require extensive ventilation ducting. The shipboard HVAC systems and associated fan rooms near combat system spaces can be significantly downsized. The shipboard chilled water system could similarly be downsized and would be used for condenser water supply and HVAC cooling coils to accommodate the Hull, Mechanical, & Electrical (HM&E) services within the combat system spaces.

PHASE I: During Phase I, the company will develop a concept for a scalable thermal management system and show the feasibility of developing a system solution to migrate from conventional shipboard approaches such as conductive and/or convective cooling. A Phase I concept will be developed, to provide a component level architecture for the thermal management system, and required system interfaces defined. The feasibility will be shown through computational fluid dynamics (CFD) analysis of the proposed system(s) to provide thermal performance data. Preliminary impacts to ship space, weight, and power (SWaP) for the system shall also be assessed during Phase I and compared to current water-to-air cooling system and forced air-cooling systems. Conductive cooling is typically implemented with Grade C quality fresh water cooler with an area/heat transfer ratio of 0.12 ft2/kw or with Grade A quality fresh water with an area/heat transfer ratio of 0.3 ft2/kw. Alternatively, convective cooling is provided through the ship's chilled water system with an area/heat transfer ratio of 1.5 ft2/kw. The Phase I Option, if awarded, should include the initial system layout and capabilities description to build a prototype in Phase II.

PHASE II: Based on the results of Phase I and the Phase II Statement of Work (SOW), a prototype modular and scalable cooling technology will be delivered that will handle thermal loadings ranging from 0.8 kW to 15 kW of heat load for MCE and CDS console applications. Phase II will include the detail design of the system to satisfy Navy requirements for thermal management and SWaP, including all performance and qualification requirements including but not limited to shock/vibration, electromagnetic interference, and bonding/grounding for system components conveyed during Technical Interchange Meetings (TIMs) following Phase I award. Land based testing will be performed at facilities qualified to validate system performance requirements in accordance with Navy standards and specifications and define system integration requirements. A Phase III qualification and transition plan will be provided at the end of Phase II.

PHASE III DUAL USE APPLICATIONS: During Phase III, the company will support the Navy in qualifying the modular and scalable cooling technology that can handle 0.8 kW through 15 kW thermal loading on AEGIS Integrated Combat system MCE and CDS consoles by providing hardware and engineering support to government shipboard installation and certification activities. This modular and scalable cooling technology will be a great help in all applications of cooling systems. They would include refrigeration, building coolers, and automobiles.

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KEYWORDS: Shipboard system cooling; chilled water-to-air cooling systems; forced air-cooling; heat generation source; Mission Critical Enclosures; Common Display System consoles

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N16A-T015 TITLE: Reduced Cost, Repeatable, Improved Property Washout Tooling for Composite Fabrication

TECHNOLOGY AREA(S): Air Platform, Materials/Processes

ACQUISITION PROGRAM: Commander Fleet Readiness Centers (COMFRC)/ Potential Application to V-22,

OBJECTIVE: To develop a process capable of producing a washout tool that can be used in the manufacturing of composite structures using tape placement, Vacuum Assisted Resin Transfer Molding Process (VARTM) and Fused Deposition Modeling (FDM) technology.

DESCRIPTION: High precision composite parts with complex shapes are currently used in aircraft engine applications. To fabricate these parts, washout tooling is required. The currently used material has issues with tolerances, consistency of tooling properties, and time to fabricate the tooling. A process that can more consistently produce the tooling in reduced time will reduce the cost of the resultant component. In addition, the development of an improved tooling processing methodology will open opportunities for many applications that to date are not considered due to the current tolerances that are achievable with current washout tooling manufacturing processes.

Composite materials are gaining increased acceptance as a structural material for Naval applications. Using composite materials for these applications allows both the material and structure to be formed at the same time. As such, using composite materials often allows for part reduction. Additional part reduction can occur using composites if the material can be accurately formed into complex shapes with high tolerances, such as those required for aircraft engine components. One way that this can be achieved is through the utilization of washout tooling. Typically, the washout material is manually poured into tooling and allowed to harden. Depending on the operator, the resulting mandrel can have varying properties and levels of consistency, and the time to produce the mandrel can vary greatly. The development of an automated process that produces the washout tooling with improved dimensional stability and with less time will result in reduced processed composite part cost. The process should produce the washout tooling such that it is highly repeatable (tolerances of +0.005” on thickness and +0.010 on everything else), low cost considering both materials and forming process ($40-$50/part of size 1.5” x 12”x 0.5”), does not require an oven post cure, and with thermal shock and impact resistance equal to ceramics and requiring minimal processing time. The material should be capable being used in autoclave processing with typical processing conditions of 350°F temperature and 100 psi pressure. In addition, the material used for the washout tooling should be environmentally friendly and should not create a hazardous waste stream.

The washout tooling must also provide the appropriate characteristics required for the production of high performance composite structures. In addition to the above mentioned tolerances, it is important that the tooling produces the finished part with the appropriate dimensions. This requires that the washout tooling have the appropriate Coefficient of Thermal Expansion (CTE) such that a finished autoclave cured part meet the tolerances required for the processed component. It should be noted that carbon/epoxy prepreg will be one of the materials that the washout tooling will be required to be compatible with.

PHASE I: Develop and demonstrate material and handling properties to produce proof of concept specimens with properties suitable for use in washout tooling applications, as detailed above. The small business shall demonstrate that the washout tooling material can be easily removed after a component has been processed at 350° F. Finally, since cost is always important, the washout material utilized must not require an oven post cure and temporary storage of washout material shall not require that it be kept under vacuum or be degraded to exposure to ambient air.

PHASE II: Based on the Phase I effort, further develop and demonstrate a repeatable process whereby the small business can produce a soluble rectangular mandrel with dimensions of approximately 1.5” x 12” x 0.5” with tolerances of +0.005” on thickness and +0.010 on everything else. These parts must also demonstrate that they are capable of handling the processing conditions typical of tape placement and autoclave curing. In addition, they need to demonstrate that the process is scalable to 2” x 20” x 0.5”. The small business must next demonstrate the ability to develop and demonstrate the process for manufacturing the soluable tooling with more complex shapes, as determined by the topic sponsor. The shape can include rectangular sections that are out of plane, or circular sections with jogs and protrusions, or foil shapes with complex curvature. In addition, the small business will scale up the processing to be able to produce mandrels with planar dimensions of a minimum 12” x 24 “. The small business must demonstrate that the manufactured component meets the dimensional tolerances established by the Technical Point of Contact (TPOC).

PHASE III DUAL USE APPLICATIONS: During Phase III, quantities of the soluble tooling will be provided to COMFRC, such as Cherry Point as well as NAWCAD Materials Engineering for final evaluation and characterization. In addition, the small business, in collaboration with the Navy monitoring team will address a selected military functional demonstration during Phase III. The final developed process will also transition to an original equipment manufacturer (OEM) where high tolerance washout tooling will be produced for production parts. The commercial aircraft industry would benefit significantly from low cost tooling material that allows for the fabrication of reproducible low cost composite parts by reducing the part count for complex shaped components. The tooling can also be used in Naval platforms (ships, subs) which could benefit from reduced part count and complex composite components.

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ject.pdf

KEYWORDS: Soluble Tooling, low cost tooling, tape placement, autoclave curing, washout tool, composite materials

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N16A-T016 TITLE: Platform for Large-scale Unsupervised and Supervised Learning

TECHNOLOGY AREA(S): Human Systems, Information Systems

ACQUISITION PROGRAM: Distributed Common Ground System-Navy (DCGS-N), Data Focused Naval Tactical

OBJECTIVE: Develop a platform which takes in large amounts of data from a variety of sources, analyzes it using sophisticated and fast algorithms and provides detailed interpretable probabilistic models as output.

DESCRIPTION: Recent advances in technology have led to the era of massive data sets which are not only larger, both in terms of sample size and dimensionality of the data, but also more complex. The data can be multi-modal, multi-relational and gathered from different sources. The massive data sets ("Big Data") introduce unique computational and statistical challenges. Traditionally, the issues of statistical accuracy of an estimator and the computational cost of implementing it have been considered separately. This approach is suitable to small-scale data sets in which computation is not a limiting factor. However, large-scale data sets require an integrated approach to statistical and computational issues [1]. With big and messy data there is an increasing need for scalable software that will fit user-specified models that include multiple levels of variation and allow the combination of diverse data sources [2]. This software should facilitate easier customization of statistical models for big data and offer robust implementation for inference over all models. Among the challenges is to find ways to incorporate problem-specific knowledge into an analysis. This often entails customizing default methods to better suit the unique characteristics of the application at hand.

Recently, there have been some promising approaches that addressed the previous challenges. For example, the DimmWitted framework [2] provides the trade-off between statistical efficiency (roughly the number of steps an algorithm takes to converge) and hardware efficiency (roughly the efficiency of each of those steps). Similarly, scalable tensor-based approaches for learning latent variable models [4] provide novel analysis for tractable tensor decomposition for many classes of latent variable models, including Gaussian mixtures, latent Dirichlet allocation and hidden Markov models. Sparse coding have also led to a number of breakthroughs in automatic processing of large volumes of textual information, to the extent that billions of text documents can be processed to extract trending topics and story lines [5]. However, such success is not matched in general media data.

There is a clear need to develop a platform for automated and efficient analysis of big data and extraction of relevant information in real time. Such platform should implement advanced mathematical algorithms that are backed by rigorous theoretical analysis and experiments.

PHASE I: Determine feasibility, advantages and limitations of existing computational algorithms to be used or develop novel algorithms for the analysis of big data. Design metrics for evaluation of the platform in Phase II including but not limited to issues related to data types (modalities), data amounts, processing time, computational efficiency, robustness of the algorithms, scalability, and adaptability. Select the data and the state-of-the-art algorithms that will be used in Phase II as a baseline for comparison and specify detailed testing and validation procedure.

PHASE II: Develop open source libraries on various platforms such as graphics processing unit (GPU), central processing unit (CPU) and cloud. Develop scalable software that will fit user-specified models. Develop a prototype platform and demonstrate the operation of the platform on simulated and real-world data. Perform detailed testing and evaluation of the platform. Demonstrate advantages of the platform in comparison to the state-of-the-art algorithms that were selected in Phase I.

PHASE III DUAL USE APPLICATIONS: The functional final system should be developed with performance specifications. Finalize the design from Phase II, perform relevant testing and transition the technology to appropriate Navy and commercial entities. Potential applications of this topic are in defense, security agencies both government and private, and law enforcement. This technology will primarily support analysis of large datasets such as satellite images, streaming audio and video signals, and text documents.

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KEYWORDS: Big data; scalable algorithms; data processing; information integration; computing; inference; learning; automated analysis

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N16A-T017 TITLE: Computational Methods for Dynamic Scene Reconstruction

TECHNOLOGY AREA(S): Battlespace, Information Systems

ACQUISITION PROGRAM: Data Focused Naval Tactical Clouds (DFNTC) FNC; Also relevant to DCGS-N

OBJECTIVE: Develop and demonstrate efficient and robust computational methods for 4D space-time reconstruction of dynamic scenes by integrating data from multiple imaging sensors and ancillary information when available. Also, develop the capability to browse the reconstructed scene from different viewpoints and at different levels of detail.

DESCRIPTION: Proliferation of imaging sensors provides the opportunity for integrating image data to reconstruct a dynamic scene, namely, reconstructing both the static background and the actors (people, vehicles, animals) moving in the scene. The imaging sensors may be stationary such as webcams and security cameras installed on buildings, and mobile such as cameras mounted on ground and air vehicles, body-worn, and hand-held smart phones. While there have been substantial advances in 3D spatial reconstruction of static scenes from multiple viewpoints, especially scenes with distinctive landmarks, 4D space-time reconstruction of moving objects has lagged behind. The three main technical challenges for reconstructing 4D space-time scenes include (i) determining correspondences for dynamic features in multiple cameras and images, (ii) reconstructing moving 3D features which may be sparse and have gaps, and (iii) space-time alignment of moving cameras with respect to the static scene. These challenges are compounded by the fact that images from cameras are taken from vastly different and changing viewpoints and have different resolutions and qualities due to variations in distance, intrinsic camera parameters, motion blur, illumination, and occlusion. We want to develop automated methods for 4D space-time reconstruction of dynamic scenes, in particular for scenes that are extended in space and events that have long durations. We also want to develop appropriate data structures and visualization methods to (iv) enable interactive browsing of the reconstructed 4D scene. The scenario is that there is a central processing place, where it receives and processes imagery from all the cameras.

PHASE I: Develop robust computational methods/algorithms for reconstruction of the 3D stationary background and the 4D space-time of moving entities. Demonstrate the feasibility of the algorithms using data from a small number of cameras (at least one of which is hand-held or body-worn) in a relatively benign urban scene with few moving entities. Estimate the scalability of the reconstruction methods to crowded scenes with many cameras and many actors moving in extended spaces over longer time periods. Also estimate the computing and storage requirements as a function of complexity of scenarios and processing time.

PHASE II: Based on Phase I effort, further develop algorithms for 4D space-time scene reconstruction by integrating images and video taken by many stationary and moving cameras. Demonstrate the performance of the algorithms applied to crowded scenes with many moving actors, in large spaces over long durations. Develop simple models of actor's behaviors and reasoning about their motion to fill potential gaps in the data coverage. Develop metrics for assessing the quality of images and whether their use would enhance or degrade the 4D scene reconstructions. Develop methods for integrating ancillary data, such as existing imagery and maps or reports that may also be available to improve the reconstructions. Develop the data-structure and visualization methods for interactive browsing of the 4D reconstructed scenes from arbitrary viewpoints and at different spatial and temporal levels of detail. The prototype system should be evaluated with publicly available data from urban street scenes.

PHASE III DUAL USE APPLICATIONS: Refine the 4D space-time reconstruction algorithms and interactive browsing methods into a final product that can be used by the Navy. Develop plans to transition a fully functional system to defense, security or law enforcement agencies for applications in after-action reviews and forensic investigations, and real-time surveillance, monitoring, and mission planning. The system should be further developed and refined according to the computational platform specifications of the intended agencies, and evaluated with publicly available data from crowded scenes and events such as fairs and sporting events. Potential applications of this topic are in defense, security agencies both government and private, and law enforcement. This technology will primarily support forensic investigations, after-action analyses, and real-time planning of actions and monitoring of events and activities.

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KEYWORDS: Scene reconstruction; images and video; ad hoc network of cameras; 4D space-time reconstruction; dynamic scene; interactive browsing

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N16A-T018 TITLE: 3D Acoustic Model for Geometrically Constrained Environments

TECHNOLOGY AREA(S): Battlespace, Human Systems

ACQUISITION PROGRAM: Advanced Underseas Weapons System (AUWS)

OBJECTIVE: Produce a 3D Acoustic model for predicting three-dimensional acoustic field parameters in environments characterized by complex geometries with variable boundary and propagation conditions. Assess the new model for use in existing, or newly developed, sonar performance estimation tools to address the optimal placement of sensors in constrained environments.

DESCRIPTION: Sonar performance models are used to assess the use of a particular sonar system for specific tasks including submarine detection, mine hunting, or swimmer detection. Feeding the performance models are acoustic models which are numerical solutions to a wave equation based on knowledge of the underlying physics and physical conditions in the prevailing environment. For active sonar systems, Transmission Loss (TL) and Reverberation Level (RL) are key sonar equation parameters derived from the acoustic fields predicted by models and used in the sonar equation to assess performance. For the majority of the existing propagation codes used in the Navy, whether based on ray theory, normal modes, wavenumber integration, or the parabolic equation, the starting point is the assumption of a horizontally stratified waveguide. Likewise, excepting volumetric contributions which are primarily biologic scattering, reverberation models are predominantly based on acoustic scattering from rough horizontal surfaces such as the seabed or sea surface. Consequently, most existing acoustic propagation models are concerned with predicting forward propagating and scattered acoustic energy. While three-dimensional acoustic models exist, or are being developed, they are based on refraction of acoustic energy owing to bathymetric changes and or internal waves or fronts that do not scatter energy strongly in the back-propagating direction. The existing models are adequate for applications in the deep ocean or open littorals, but sonar operators are increasingly being asked to perform tasks including navigation or detection in more confined waterways such as rivers or ports. However, models are generally not available for predicting the acoustic field in such highly geometrically constrained and dynamic environments. These environments can be characterized by vertical or near vertical boundaries such as piers and breakwaters and have large tidally driven depth variations over short time periods. They also may be populated with large scattering objects such as deep draft vessels and mooring dolphins that impact the acoustic field.

We seek a capability to model the three-dimensional acoustic field, including propagation, scattering, and reverberation in complex environments. Approaches should include, but are not limited to, predicting complex pressure from a point source, with a minimum frequency of 1 kHz, placed arbitrarily within a representative harbor environment, e.g. Mayport Basin, Florida. Solutions should provide ¼ wavelength resolution for area dimensions greater than six million square feet for a typical depth of 50 feet. The environment may be open to the sea, but must include at least one vertical boundary representative of a quay wall, a breakwater, and a blockage representing a deep draft vessel with draft of 60%-90% of the channel depth. A broadband model is preferred, but a narrowband solution is acceptable if accompanied by a conceptual plan for development into a full broadband solution. Computational efficiency and speed is not a priority, but will be given consideration. Amongst other things, it is expected this capability will form the basis for existing or new sonar performance estimation tools. In particular, the model combined with an appropriate decision aid could address the optimal placement of sensors in complicated environments for tasks including establishing underwater communication links or harbor surveillance.

PHASE I: Define and develop a concept to predict acoustic field parameters in highly geometrically constrained underwater environments. Concepts should include approaches to predict the three-dimensional complex acoustic pressure field for a point source in representative environments such as described above. Develop concepts for incorporating the new acoustic model into sonar performance estimation models, existing or proposed, to address optimal placement of acoustic sensors to achieve basin wide communications coverage or object detection.

PHASE II: Produce an acoustic model capable of generating a 3D complex acoustic pressure field in a geometrically constrained environment described as for Phase I. Perform initial validation and verification testing of the new model and document changes in the acoustic field for changes in source position and the presence or absence of quay walls, breakwaters, deep draft vessels, etc. Document the associated mathematical development and implementation in technical reports and user manuals. Provide details on software and hardware requirements for the new code. Provide a plan for integrating the new acoustic model into existing sonar performance estimation models or a development plan for a new integrated sonar performance model.

PHASE III DUAL USE APPLICATIONS: Complete the integration of the acoustic model into an existing sonar performance estimation model, or complete the development of a new integrated model for optimal placement of acoustic assets in confined environments. Design and deliver a prototype TDA to the AUWS program to guide acoustic communications sensor placement. The baseline 3D acoustic model should be submitted for consideration in the Oceanographic and Atmospheric Master Library (OAML) suite of Navy applied acoustics codes. There is potential to spin off the technology for private security clients in the protection of marinas and private or commercial vessels.

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KEYWORDS: underwater acoustics, propagation, scattering, communications, sonar, 3D acoustic modeling, sonar simulation, performance estimation

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Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T019 TITLE: Thermal Barrier Coatings for Long Life in Marine Gas Turbine Engines

TECHNOLOGY AREA(S): Battlespace, Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: FNC EPE FY15-02 Gas Turbine Developments for Reduced Total Ownership Cost a

OBJECTIVE: To develop thermal barrier coatings (TBCs) and a coating model that enables longer service and prediction of corrosion, oxidation and overall degradation when exposed to marine Naval environments as a function of corrosivity, stress, and higher temperature combinations via integrated computational material engineering.

DESCRIPTION: Materials for current marine gas turbine engines were developed and testing during 1960-1990s to resist degradation from Type I hot corrosion (1600-1700ºF) and Type II hot corrosion (1250-1350ºF). This development for USN marine gas turbines produced the highly reliable marine gas turbines that exist today where engines are not operated at full power where there may be only occasional spikes to 1700ºF. Navy engines operating at less than full power mode allowed these hot section materials to exist for 20k hours or more before repair or replacement was required.

Navy gas turbine operations that typically run at less than full power are inefficient compared to engines that are operated much closer to full power (and higher engine temperatures). The increased temperatures for marine gas turbine engines will permit greater engine efficiencies and the potential for greater power that will be needed in the future for weapon systems such as laser and electromagnetic rail gun. The greater power provided by ship engines, along with energy storage devices, will enable less supplemental power sources such as fuel cells and batteries that will add weight to the ship.

However, higher operational temperatures in marine engines may accelerate alloy and coating diffusion and interdiffusion interactions that may negatively affect the protective capabilities of overlay and diffusion coatings. The average engine temperatures are estimated to rise about 150-250ºF with occasional excursions to approximately 1850ºF. At these upper operating temperatures, oxidation rather than hot corrosion will be the prevailing reaction on coatings and alloys. Thus, The USN is entering a new region of marine gas turbine operations that will involve both corrosion and oxidation attacks materials on gas turbine engine hot sections. These are two totally different types of attack mechanisms. In addition, the USN shipboard environment (the marine environment) is high in salt laden air and water, coupled with air and fuel sulfur species that cause aggressive corrosion in gas turbine hot sections.

There is evidence that engine materials operating at these higher temperatures will dramatically experience shorter life (<10k hours) before the engine needs to be replaced. Thermal barrier coatings (TBCs) are regularly used in aero engines and have the potential to lower the substrate temperatures about 200-300ºF. Thermal Barrier coatings applied over the overlay or diffusion coatings could preserve the coating chemistry and structure and consequently maintain hot corrosion and oxidation resistance. Because of fuel and air contaminants, reactions have occurred that have shorted TBC life well below 20K hours because of spallation. Research must be performed to avoid spallation. There have been earlier efforts to evaluate TBCs in a simulated marine engine test environment, but spallation by salt intrusion into the TBC and subsequent salt solidification in the TBC has led to spallation. Increased understanding derived from aviation engine research and the utilization of computational methods will develop TBCs that will be resistant to spallation. This research would develop the understanding and processing of TBCs for sustained service for up to 20K hours marine gas turbine environments that will be experienced in the future.

PHASE I: Demonstrate an understanding of what differences exist between aviation and marine propulsion and what influences TBC spallation. Initiate correlations that should begin to formulate the ICME (integrated computational material engineering) model framework to promote long TBC life (goal: > 20K hours) and assist in maximizing corrosion and oxidation resistance by changes in coating chemistry and structure while not impacting fatigue, creep, or substrate strength of the substrate alloys. It is suggested that the starting TBC be yttria-stabilized zirconia. Lastly, perform a short-term (~200 hours) high temperature test to validate the feasibility of the ICME model.

PHASE II: The ICME framework shall be further expanded to include compatibility of the TBC to different bond coats as well as further development, modification, and maturation of the ICME model. Coating and engine original gas turbine equipment manufacturers (OEMs) is encouraged for advice and direction for further developments of the ICME models and strategies to enhance TBC life in marine shipboard engine applications. The performer shall correlate into the ICME-derived model the interaction of chromium and aluminum content in a coating that leads to the formation of chromia or alumina scales. Coatings on several alloys shall be tested to determine coating compatibility and assess impact of coatings on alloy substrate properties in a burner-rig or similar test environment that includes salt ingestion. Coatings shall be applied onto alloy substrates by at least one recognized commercial coating process (line-of-sight and/or non-line-of-sight). The expected deliverables will be: (1) optimized corrosion and oxidation-resistant coatings for a given set of alloys and (2) an ICME-derived model that would predict and assist in the development of future TBC systems (alloy, bond coat, TBC, TBC strategy to minimize spallation with Marine engine operational environment) that are compatible with multiple alloy substrates.

PHASE III DUAL USE APPLICATIONS: The ICME model will be further developed and matured through the expansion of TBC chemistry and structure with the selected strategies to mitigate salt intrusion into the TBCs that tend to cause premature cracking. Coating developed under the ONR FNC program (FNC EPE FY15-02 Gas Turbine Developments for Reduced Total Ownership Cost (TOC) and Improved Ship Impact) should be tested in a burner-rig or similar test environment that includes salt ingestion. The small business should engage with a marine engine OEM to have an appropriate TBC system applied on select static and/or rotating engine components of a current Navy engine and testing in cycling temperature test. The expected deliverables will be: (1) a TBC(s) compatible to corrosion and hot corrosion-resistant bond coat substrates, (2) TBC(s) resistant to spallation in the marine environment, and (3) an ICME-derived model that would predict and assist in the development of future TBC systems (alloy, bond coat, TBC, TBC strategy to minimize spallation with marine engine operational environment) The bond coat and salt intrusion into TBC behavior should be understood to minimize long-term interactions with TBCs that will promote long-term TBC life. The small business needs to engage with a marine engine OEM to further develop the TBC technology for incorporation in the current and future Navy ship engines. Development of long-lived TBC systems able to withstand hot corrosion, oxidation, and spallation at higher temperatures for U.S. Navy applications will also enable more efficient service for commercial applications that employ industrial gas turbines. Marine gas turbine engines are industrial gas turbines that are intended for Naval use. Successful development of better coatings for the current alloys, capable of extended service in the highly corrosive Naval operating environment, should enable subsequent use in commercial applications such as cargo ships, cruise ships, ferries, and tankers if the business case justifies the results.

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KEYWORDS: Thermal Barrier Coatings, spallation, bond coats, TBC failure, environmental deposits, marine engines

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N16A-T020 TITLE: Embedded Space Analytics

TECHNOLOGY AREA(S): Information Systems

ACQUISITION PROGRAM: FNT FY15-02 DF Naval Tactical Cloud, PMMI (MCSC), DCGS-N (PMW 120)

OBJECTIVE: Develop a capability to detect people, places and events of interest from big data by developing anomaly detection and supervised learning algorithms that can operate effectively on compressed data and data embeddings.

DESCRIPTION: Model based understanding technology has enabled machines to generate huge graphs (millions of nodes and billions of edges) from diverse sources (structured and unstructured data) [3]. Even for capable machines, real-time operation of complex anomaly detection and supervised learning algorithms requires a reduction in data volume. There exists a variety of data embedding algorithms that achieve a reduction in graph dimensionality through unsupervised or semi-supervised techniques [2]. The goal of this topic is to mature algorithms to understand the significance of the movement of entity vector representations over time in embedded spaces [1]. Specific technical challenges include the development of: 1) learning algorithms that allow data vectors to be characterized in a behavior space; 2) anomaly detection algorithms that generate useful alerts of real entities; 3) supervised learning algorithms that predict the meaning behind the movement of entities in embedded spaces; and 4) system scoring of the confidence of knowledge generated.

Enabled by service oriented (SOA) and cloud architectures, intelligence programs have unprecedented access to big data whose detailed content is represented by even larger graphs. Advances in dynamic graph analysis are needed to show the military value of holding and indexing these big data stores to strategic and tactical use cases. Algorithms to generate lower dimensional graphs, and supervised learning algorithms that can be applied to data vector representations, currently exist. Progress has been made on analyzing static embedded data representations such as inferring missing data and classification decisions. More work is needed, however, to link vector positions to real world meaning, particularly over time. Dynamic analysis techniques are less developed but needed for the generation of time sensitive alerts from streaming data such as for change detection and event discovery. Research institutions and universities are active in the development of unsupervised (e.g. anomaly detection and data embeddings) and supervised learning algorithm development. The dynamic algorithms needed to understand the movement of entity vector representation over time is a natural extension of their current research activity.

A mature system should also be easy to use and compatible to the computational architecture of a transition program of record.

Tasks to consider include the following: 1) Entity/ relationship declarations in support of knowledge discovery that are task/ mission essential; 2) Unsupervised and semi-supervised methods for the construction of embedding spaces from very large graphs that are rational and human understandable (not black boxes); 3) Supervised learning algorithm development to support dynamic inferencing of embedded spaces; and 4) Visualizations of high order embedded spaces at lower dimensions that are user instructive.

PHASE I: For a bounded set of data and information requirements, show an embedded space representation of a large graph and train classifiers to learn the relationships between embeddings and real world entity descriptors. Produce a use case and workflows relevant to a military customer and/or commercial market. Provide a proof of concept demonstration for identified transition targets. During the Phase I effort, performers are expected to identify metrics to validate performance of analytic products with the goal of reducing the technical risk associated with building a working prototype should work progress. Performers should produce Phase II plans with a technology roadmap and milestones.

PHASE II: Produce a prototype system based on the preliminary design from Phase I. The prototype should enable users to infer information not overtly evident in the data and provide measures of effectiveness. In Phase II, performer may be given data by the Government to validate capabilities. The small business should assume that the prototype system will need to run as a distributed application in a cloud architecture that could scale to millions of nodes and billions of edges. Phase II deliverables will include a working prototype of the system, software documentation including a user’s manual, and a demonstration using operational data or accurate surrogates of operational data.

PHASE III DUAL USE APPLICATIONS: Based on Phase II effort, deliver to the Navy a system capable of deployment and operational evaluation. The system should consume available operational and open source data sets and focus on areas/missions that are of interest to specific transition programs or commercial applications. The system needs to have an easy to use human systems interface. The software and hardware should be modified to operate in accordance with guidelines provided by transition sponsor. Internet search engines would benefit from the maturation of data retrieval based on distances between concepts in embedded spaces. Currently, information retrieval is limited to word searches with some support to graph searches. Information retrieval based on second or higher order association (similarity between feature vectors) would transform content delivery by improving returns to "you might also like".

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KEYWORDS: Data embeddings; Graph theory; Data science; Advanced analytics; Cloud computing; Unsupervised learning; Supervised learning

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Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T021 TITLE: High Performance Energetic Propellant Ingredient Process Research and Development

TECHNOLOGY AREA(S): Materials/Processes, Weapons

ACQUISITION PROGRAM: PEO IWS; LCS Surface Warfare Mission Package; Hellfire

OBJECTIVE: Scale-up, characterize, and provide homogeneous samples of new high density energetic materials sufficient for manufacturing and characterizing a representative propellant formulation. Methods for the preparation of representative advanced energetic ingredients whose energy output exceeds HMX but with superior safety and handling characteristics are sought. The ultimate goal is to create new ingredients which have an optimized chemical route for their preparation that minimizes the number of process steps, and minimizes the costs of starting materials and reagents.

DESCRIPTION: To meet the needs of the future military, there is a continuous effort to develop new materials with higher performance and increased insensitivity to thermal degradation and physical shock and impact. Researchers have adopted many approaches to overcome the technical issues of combining performance with insensitivity, including developing novel energetic ingredients with reduced sensitivity. Our currently used energetic ingredients have been in use, in some cases, for over a century. Without new high performance, low sensitivity energetic ingredients, we will continue to be unable to address the paradox of increased energy with decreased sensitivity.

In order to demonstrate viability in an energetic formulation which permits a weapon system to meet mission capability requirements, a new energetic material must demonstrate reproducibility at low cost. Furthermore, the formulation utilizing a new ingredient must exhibit sufficient mechanical and chemical robustness to meet service requirements over a wide temperature range to meet mission capability requirements. To meet these stringent conditions, the energetic material must exhibit stability against chemical and physical degradation under storage and operational environments throughout a service life that can exceed 20 years. Impact, friction, ESD, density, and vacuum thermal stability (VTS) should meet or be improved over the properties of HMX. The next generation of energetic ingredients will permit propulsion system designers to meet the requirements for smaller systems with increased performance and reduced vulnerability to thermal, impact and shock stimuli while eliminating or reducing the use of ammonium perchlorate – a long-term environmental issue for the DoD. The focus of this effort is to identify promising candidate energetic ingredients, scale-up and optimize a process for manufacturing them, and then produce sufficient quantity to allow a propellant formulator to manufacture and characterize their performance in a propellant composition.

PHASE I: Design and prepare conceptual synthesis routes to new oxidizer molecules. Down select and synthesize up to 25-g samples of these new materials by considering how these materials properties compare to the following target properties:
Density > 1.8 g/cc
Oxygen content > CO Balance
Melting Point >200°C
Minimize the number of of Synthetic Steps

Low Vapor Pressure
Sensitivities better than TNT
Low Hydrogen & Carbon; High Oxygen & Nitrogen content

Provide characterization, analysis, and delivery to government laboratories for evaluation.

PHASE II: Based on Phase I effort, scale-up and optimize the synthesis process to pound quantities for larger-scale evaluation. Investigate process research and establish parameters to develop process for manufacturing pure material for delivery of 2000lb per year.

PHASE III DUAL USE APPLICATIONS: Transition technology to next generation propulsion and ordnance systems per appropriate PEO/PMS/PMA road maps. Provide costing and data package for pilot production of materials based on requirements and need. Examples include missile systems and new underwater explosives. Potential custom oxidizer applications in synthesis can be envisioned, particularly for stable, long-shelf life material for commercial heavy lift space craft such as Space X. Other potential applications may be found with NASA.

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KEYWORDS: Oxidizer; Propellants; Propulsion; Explosives; High-Density; Scale-up

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Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T022 TITLE: Integrated Computational Material Engineering Approach to Additive Manufacturing for Stainless Steel (316L)

TECHNOLOGY AREA(S): Ground/Sea Vehicles, Materials/Processes

ACQUISITION PROGRAM: EPE-17-03 Quality Metal Additive Manufacturing

OBJECTIVE: Develop an Integrated Computational Materials Engineering (ICME) approach to the Additive Manufacturing (AM) of stainless steel (316L), to predict final metal part quality and performance.

DESCRIPTION: Many Naval systems have long mean logistics delay times for expensive, limited production parts that are typically cast. There are part obsolescence issues with aging platforms, and diminishing sources of supply, which delay part production and increase part cost. NAVAIR and DLA have documented the 8-28 month cycle required to establish a new source of supply for limited production cast parts. Part studies have shown that establishing new AM parts to replace limited production cast parts is generally much faster and will have a cost advantaged when compared to obsolete or out of production cast parts, which currently hamper system readiness.

Integrated Computational Materials Engineering (ICME) provides the physics-based computational tools to quantify and link the interdependent Processing-Structure-Property-Performance relationships for materials. These tools tie the processes that produce parts to their material properties to ensure the design of the right material for an application. The application of ICME to the design of AM will help speed new materials and processes, where AM is appropriate, to reduce the time and cost of process/part qualification and certification. This will enhance operational availability and decrease total ownership cost for Navy systems. For this reason, ICME is a critical enabler in the Navy's AM Roadmap and implementation strategy.

For this project, the specific application is the design of additive manufacturing processes for stainless steel 316L aerospace parts using a powder-based approach with directed energy (laser or e-beam). The ICME tools must model, simulate, and predict part quality and performance based on input process parameters. This must include local composition, microstructure (including porosity and other defects), residual stresses and/or distortion, and mechanical properties. The intended use for these tools is to guiding part design, process development, and certification for use.

Modeling and simulation tools should be developed and validated to: predict production reliability; model accurately AM processes and part fabrication; quantify dimensional, microstructural, and mechanical property uncertainty; predict accurately residual stress and distortion; predict accurately number, percent, and location of defects, e.g., porosity; support selection of the optimal build strategy (energy, feed rate, path / hatch space); design of support structure; predict resultant microstructure; predict resultant material properties; assess part functionality based on key design features; provide a probabilistic framework to support rapid qualification or processes and parts; and establish and output upper and lower limits for key process parameters to ensure quality in process controls during later fabrication.

PHASE I: Determine the architecture for the ICME tool set, and define the existing and needed models to fill this architecture. Identify the existing thermo-physical and structure-property-processing datasets for 316L and map a plan for filling in the required data necessary for the toolset. Describe a framework for the subsequent qualification and certification of parts and processes using this ICME toolset.

PHASE II: Assemble and as necessary develop, and validate physics-based models to link additive manufacturing processing parameters to materials structure and subsequent properties. As necessary for computational efficiency, develop and validate surrogate models for these physics-based models. Develop a validated materials database needed to support these models and verify and validate the individual models. Demonstrate prediction of location-specific microstructure, defects, and properties (including predictions for variability) for a test geometry and set of processing instructions (that is, STL file, beam history profile, etc.) for a particular additive manufacturing system of choice by the development team. The technical metrics for ICME tools in Phase III are property prediction capability as a function of process and geometry: measured value is +/- 10% (T) and +/- 5% (O) of predicted ICME value with a confidence of 90%.

The successful project will provide an overall design tool architecture description with interface specifications for the necessary software tools and materials data. The documented software tool interface specifications will include component tool execution approach (for example, static linked subroutine, spawned mpi process, etc.), data I/O requirements and formats (for example, input list of five 64-bit integers representing in order …, followed by five arrays of 64-bit IEEE floating-point data of size … representing …), and message-passing methods (such as an ASCII data file named *fred.inp* formatted as…). The materials data specification will include a full list of the necessary materials data, including properties, error bounds and/or uncertainty, metadata requirements, and data and metadata format for use. The project reporting will include all data developed in this project in the specified formats.

PHASE III DUAL USE APPLICATIONS: Complete development of Integrated Computational Materials Engineering (ICME) process design tools that link interdependent AM Processing-Structure-Property-Performance relationships. Demonstrate the tool by designing processing approaches for component parts of industrial interest specified by the Navy Program Manager, and comparing critically the as-produced parts to the predictions using a combination of destructive testing and non-destructive inspection techniques. The technical metrics for ICME tools in Phase III are property prediction capability as a function of process and geometry: measured value is +/- 10% (T) and +/- 5% (O) of predicted ICME value with a confidence of 90%. Transition the final ICME process design tool to the Navy for its intended use. The material of interest, 316L stainless steel, is a common material for industrial applications requiring moderate strength and good corrosion resistance. It is also a significant material in the biomedical industry for surgical tools, and for implant applications. The agile precision manufacturing of specialty components from this material can lower the cost dramatically of these specialty items, and enable new commercial applications in high-reliability applications.

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KEYWORDS: Additive Manufacturing, ICME, materials engineering, stainless, modeling and simulation, physics, 316L

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Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T023 TITLE: Epitaxial Technologies for Gallium Oxide Ultra High Voltage Power Electronics

TECHNOLOGY AREA(S): Electronics, Ground/Sea Vehicles, Weapons

ACQUISITION PROGRAM: PEO SHIPS: PMS 320 Electric Ships Office

OBJECTIVE: Develop gallium oxide epitaxial growth system to enable the realization of novel high voltage (greater than 20kV) power electronic switching and pulse power devices.

DESCRIPTION: Future Navy ships will require high power converters for applications such as rail gun, Air and Missile Defense Radar (AMDR), and propulsion on DDG-51 size ship platforms. High voltage, high efficiency power switches are required to achieve the needed power density. Monoclinic beta(ß)-Ga_2O_3 possesses a large energy bandgap of 4.8eV and high breakdown field of 8 MV/cm. These properties motivate the development of Ga_2O_3 for high-power/high-voltage electronic devices. Additionally, the extremely low intrinsic carrier concentration of ni = 1.8x10-22 cm-3 of Ga2O3 enables low generation/recombination rates and thus low leakage currents in a thick drift region. Theoretically, a vertical Ga2O3 device designed with a 30 µm thick n-type drift layer will operate with a 24kV breakdown. Nevertheless, the technology to produce a high-voltage Ga2O3 device structure is currently unavailable. The primary limitation is the extremely low-growth rate of current Ga2O3 epitaxy systems, e.g., metal-organic chemical vapor deposition (MOCVD). The secondary but related limitation is the controlled n-type and p-type doping of Ga2O3.

The growth of a thick, low-doped Ga2O3 drift region has proven challenging with current reactor designs. Current literature on Ga2O3 epitaxy reports growth rates on the order of a hundred nm/hour, which reasonably excludes the growth of thick drift layers. [1, 2] A key issue for Ga2O3 epitaxy is achieving a high growth rate while maintaining high epitaxial quality. A reactor technology is needed to address the specific reaction kinetics of the Ga2O3 at the gas/solid (substrate) interface as well as to minimize undesirable gas-phase nucleation that depletes the reactant supply and creates deleterious particulates. Additionally, the reactor design must enable controlled low-level (<1x1015 cm-3) n-type doping in this high-growth rate regime. In situ measurement tools can facilitate the growth of high quality Ga2O3. [3, 4]

Achieving p-type doping in Ga2O3 is difficult, which, given the similar p-type doping limitations in related metal-oxide semiconductors, is attributed to the presence of n-type vacancies formed during the growth process. The literature on n-type doping of Ga2O3 is mixed, which again may suggest that proper design of the reaction chamber is necessary to account for the specific kinetics of Ga2O3 material system. [5, 6] An optimal high-voltage power electronic device also necessitates a reactor design able to controllably deposit Ga2O3 at high n- and p- doping levels (>1x1019 cm-3). [7, 8]

Proposed growth system should meet the following thresholds:
• Deliverable Design Characteristics Value
• Controllable deposition with low-concentration (<5x1016 cm-3) n-type Ga2O3 layers
• n-type Ga2O3 with growth rates above 2 um/hr in Phase I and above 4 um/hr in Phase II
• nm-scale thickness uniformity at sub-nm RMS roughness levels
• High-concentration (>1x1019 cm-3) n-type, thin (< 50 nm) device layers
• High-concentration (>1x1018 cm-3) p-type, thin (< 50 nm) device layers

PHASE I: Determine feasibility, establish a plan, and describe the epitaxial growth tool features and issues for the design and development of a deposition system that can controllably deposit low-concentration (<1x1015 cm-3) n-type Ga2O3 layers with growth rates above 2 um/hr (>10 X current state-of-the-art). Determine the feasibility, establish a plan, and describe the epitaxial growth tool features and issues that can achieve thin (< 50nm) high-concentration (>1x1019 cm-3) n-type and p-type Ga2O3 layers and an appropriate ternary with nm-scale thickness uniformity at sub-nm RMS roughness levels. Final report should convince that the proposed product can be properly designed to address the above desired and required features and be achieved if Phase II is awarded. The small business will provide a Phase II development plan addressing technical risk reduction.

PHASE II: Develop a fully-functional epitaxy system having in situ characterization tools and capable of producing a thick, low-concentration (<5x1014 cm-3) n-type Ga2O3 drift layer (>30µm) as well as high-concentration (>5x1019 cm-3) n- and p-type doped thin (sub 100 nm) device layers within the same growth run. The system should demonstrate epitaxial growth rates of at least 4um/hr. A prototype of the fully operational system with appropriate control software will be delivered to the Navy and is required by the end of Phase II for evaluation.

PHASE III DUAL USE APPLICATIONS: Phase III shall address the commercialization of the product developed as a prototype in Phase II. The small business is expected to work with suitable industrial partners for this transition to military programs and civilian applications. The expected final state of this product will match the requirements given in Phase II and will allow for the tool to be installed, certified, and operated within standards of a modern semiconductor fabrication facility. An epitaxy system of this design will enable cost-effective semiconductor based high-power devices for solid-state transformers to replace electromagnetic transformers for the electric grid, rail traction, large-vehicle power systems, and wind turbines.

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KEYWORDS: Gallium Oxide, Deposition System, Wide Bandgap Semiconductor, High-Power Electronics, High Power Converters, epitaxy system

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Questions may also be submitted through DoD SBIR/STTR SITIS website.

N16A-T024 TITLE: Multi-Access Optical System for Communications and Sensing Applications

TECHNOLOGY AREA(S): Battlespace, Information Systems, Sensors

ACQUISITION PROGRAM: SSPDD, SHD-FY16-05 “SURFACE SHIP PERISCOPE DETECTION AND DISCRIMINATION”

OBJECTIVE: Develop a small form-factor, highly scalable and affordable point-to-multi-point optical sensing and communications architecture for data transfer between numerous sensors and platforms in multiple environments.

DESCRIPTION: For tactical and strategic awareness the Navy deploys a wide range of platforms and sensors for surveillance, detection, localization, tracking and characterization [1]. With emerging unmanned, autonomous, and distributed technologies a large number of platforms and sensors can be located in the battle space, and data must be retrieved and shared for complete situational awareness. For this application, optical communications has numerous advantages including high data rates, immunity to interference, and low probability of interception and detection [2, 3]. However, traditional laser communications systems have been designed primarily for single point-to-point links and are based on mechanically-intensive and non-scalable technologies. A multi-point system extends existing methods by taking advantage of both temporal and spatial dimensions. Employing traditional design approaches to the emerging multi-point applications requires too much SWaP (Size, Weight, and Power) and cost-to-scale with future needs. The intent of this topic is to develop an optical point-to-multi-point communications system which is low SWaP (Weight: <50 lbs, Size: <1ft Dia X 3ft High, Power: <3KW Total Electrical), highly scalable (Spectral Scalability: Visible though IR), and affordable (Cost: < $250K / unit). The technology approach should scale to large multi-point topologies, agilely track moving terminals, be compatible with communication and sensing through air or water, and be robust compared to existing mechanical approaches.

PHASE I: Determine feasibility for a Multi-Access Optical System for Communications and Sensing Applications. Develop the initial architecture, identify key technologies, and model the system advantages and tradeoffs. Specific areas of interest include multi-point scalability, speed of tracking, and range performance.

PHASE II: Based on the results of Phase I effort, develop a Multi-Access Optical System for Communications and Sensing Applications prototype for evaluation. The prototype will be evaluated to determine its capability in meeting the performance goals defined in Phase II Statement of Work (SoW) and the Navy need for agile aperture steering technology. Demonstrate the ability to support both laser communications and LADAR sensing applications. The prototype design should provide 360-degree angular coverage and no less than 10 degrees elevation coverage. Deliver a prototype to the Navy for evaluation. The team will perform detailed analysis to ensure materials are rugged and appropriate for Navy application. Limited environmental, shock, and vibration analysis will also be performed (note that testing is not intended to meet formal shock, vibration or temperature requirements. It is intended to identify problem areas that might prevent transition of the design to Phase III).

PHASE III DUAL USE APPLICATIONS: Apply the knowledge gained in Phase II to build, deliver and integrate an advanced agile laser communication/LADAR combined system, suitably packaged for shipboard use (note that the intent here is to use the information learned during Phase II testing to have units capable of surviving unattended aboard ship for roughly 6 months. After that period, those units are swapped out for new or reconditioned units). Support the Navy for test and validation to certify and qualify the system for Navy use. Explore the potential to transfer the agile aperture laser system to other military and commercial systems (undersea, airborne, and ground vehicle agile laser communication/LADAR systems). Market research and analysis shall identify the most promising technology areas and the team shall develop manufacturing plans to facilitate a smooth transition to the Navy. Development of robust multi-access optical communications technology could greatly enhance the effectiveness of sensors and unmanned platforms by maintaining high-speed communications, and reducing local signal processing requirements. This in turn reduces power consumption, which increases platform/sensor endurance. New optical approaches could also apply to commercial imaging and tracking applications in security, industrial automation, and health care sectors.

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KEYWORDS: Optics, Communications, Photonics, Laser, Sensors, LADAR

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N16A-T025 TITLE: Hybrid Unmanned Air / Underwater Vehicle for Explosive Ordnance Disposal (EOD) and Mine Countermeasures (MCM)

TECHNOLOGY AREA(S): Air Platform, Ground/Sea Vehicles

ACQUISITION PROGRAM: PMS-408 Expeditionary Unmanned Neutralization System (EUNS)

OBJECTIVE: Develop a Hybrid Unmanned Air / Underwater Vehicle capable of operating in air and underwater interchangeably.

DESCRIPTION: Unmanned airborne vehicles (UAVs) and unmanned underwater vehicles (UUVs) are used by the Navy to locate objects in the ocean. Unmanned airborne vehicles have been demonstrated to land on the ocean surface and even penetrate the surface and travel small distances underwater but not return to the surface. Recent advances in vehicle control technology and propulsion systems make it feasible to construct innovative unmanned vehicles that can operate in air and underwater interchangeably (i.e. enter the water and return to the surface to resume operations in air). This type of vehicle will be referred to as a Hybrid Unmanned Air / Underwater Vehicle (HUA/UV). Nature provides examples of birds that have developed superior strategies for searching large areas of the ocean to hunt for food beneath the surface. These birds are able to fly rapidly in air above the ocean surface because there is less drag on their bodies and enter the higher drag environment of the water only when they locate a food source under the surface. They then swim underwater to capture their source of food and return to the surface to repeat the sequence if necessary. These birds conserve energy (i.e. fuel) by avoiding the higher body drag associated with the water which allows them to explore large areas of the ocean in their hunt for food. The HUA/UV will exploit this same strategy and will be capable of rapidly covering large areas of the ocean to locate objects in the ocean. The HUA/UV must be able to complete the following sequence: transit in air to a location on the water surface, enter the water, transit underwater to inspect an underwater object using a video camera, exit the water, and transit in air back to the point of launch. This sequence must be accomplished with the HUA/UV operating under full control. Technical risks include control, maneuverability, stable water entry and exit, efficient propulsion in air and water, payload capacity, and structural integrity.

PHASE I: Design and determine feasibility for the development of a Hybrid Unmanned Air / Underwater Vehicle (HUA/UV) that can fly in air and swim underwater to inspect an underwater object. An in depth analysis should identify the key parameters associated with the design of a proof of concept HUA/UV capable of carrying payloads of 10 to 30 pounds. The HUA/UV must be capable of transitioning from controlled stable flight in air to controlled stable flight underwater to water depths ranging from 5 to 40 feet.

PHASE II: Further develop and demonstrate a Hybrid Unmanned Air / Underwater Vehicle (HUA/UV) that can complete the following sequence for multiple underwater objects: 1. Mission Start: transit in air to a predetermined location on the surface of the water, 2. Object Inspection Start: enter the water, transit underwater to collect video imagery of the object, exit the water, and transit in air to another predetermined location on the surface of the water (repeat the inspection process for up to ten (10 objects), 3. Mission End: after inspection of the last underwater object transit in air back to the point of initial launch (end mission). The objects will be positioned in the water at depths ranging from five (5) feet to forty (40) feet. The HUA/UV must be operating under controlled, stable flight conditions and the imagery of the object should be provided to the operator in real-time. The system should be capable of carrying a payload of up to 30 pounds. The HUA/UV should be equipped with a video camera to inspect the underwater object and the necessary means of communicating to the operator in real-time (in air and underwater). An in-depth analysis should show the system trades of size, weight and power consumption for an operational system capable of carrying payloads up to 50 pounds, and expected mission times (as described above) to support operational missions.

PHASE III DUAL USE APPLICATIONS: If Phase II is successful, the small business will provide support in transitioning the technology for Navy use. The small business will develop a plan to determine the effectiveness of the Hybrid Unmanned Air / Underwater Vehicle (HUA/UV) in an operational environment. The small business will support the Navy with certifying the HUA/UV for operational sustainability. As appropriate, the small business will focus on scaling up manufacturing capabilities and commercialization plans. There is commercial potential associated with the inspection of commercial waterways to prevent collisions with debris.

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KEYWORDS: Hybrid Unmanned Aerial Underwater Vehicle, Quadrotor Helicopter, Waterborne Improvised Explosive Devices, Mine Countermeasures, Unmanned Vehicle, Explosive Ordnance Disposal

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